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INSTRUCTION MANUAL
2750L-P/4500L-P

California INSTRUMENTS

Invertron® AC POWER EQUIPMENT

Convertron® DC POWER EQUIPMENT

California Instruments Corporation

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California INSTRUMENTS

Revision A

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INSTRUCTION MANUAL

2750L-P/4500L-P

Invertron®

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SECTION 1

INTRODUCTION AND SPECIFICATIONS

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of all power systems that use the 4500L-P or 2750L-P.

1.2 GENERAL DESCRIPTION

This power system is a high efficiency power source that provides a low distortion output. The output can be configured in either a single or three-phase configuration.

A number of Power Sources can be configured to supply full output power up to 27000VA. Table 1-1 shows the output VA per phase for each of the available power system models. The table also shows that increased power is available at a reduced operating temperature of 35°C.

MODEL	NUMBER 4500Ls	OUTPUT VA PER PHASE 50°C	OUTPUT VA PER PHASE 35°C	NUMBER PHASES
2750L-1P		2700	3000	1
2750L-3P		900	1000	3
4500L-1P	1	4500	5000	1
4500L-3P	1	1500	1667	3
9000L/2-1P	2	9000	10000	1
9000L/2-3P	2	3000	3333	3
13500L/3-1P	3	13500	15000	1
13500L/3-3P	3	4500	5000	3
27000L/6-1P	6	27000	30000	1
27000L/6-3P	6	9000	10000	3

TABLE 1-1

OUTPUT VA PER PHASE

Full power is available at the maximum output voltage on either of two voltage ranges. The standard voltage ranges are 135 and 270. Three optional voltage range pairs are available: 67.5/135, 156/312 and 200/400.

All "P" Power systems will deliver full power from 45 to 2000 Hz.

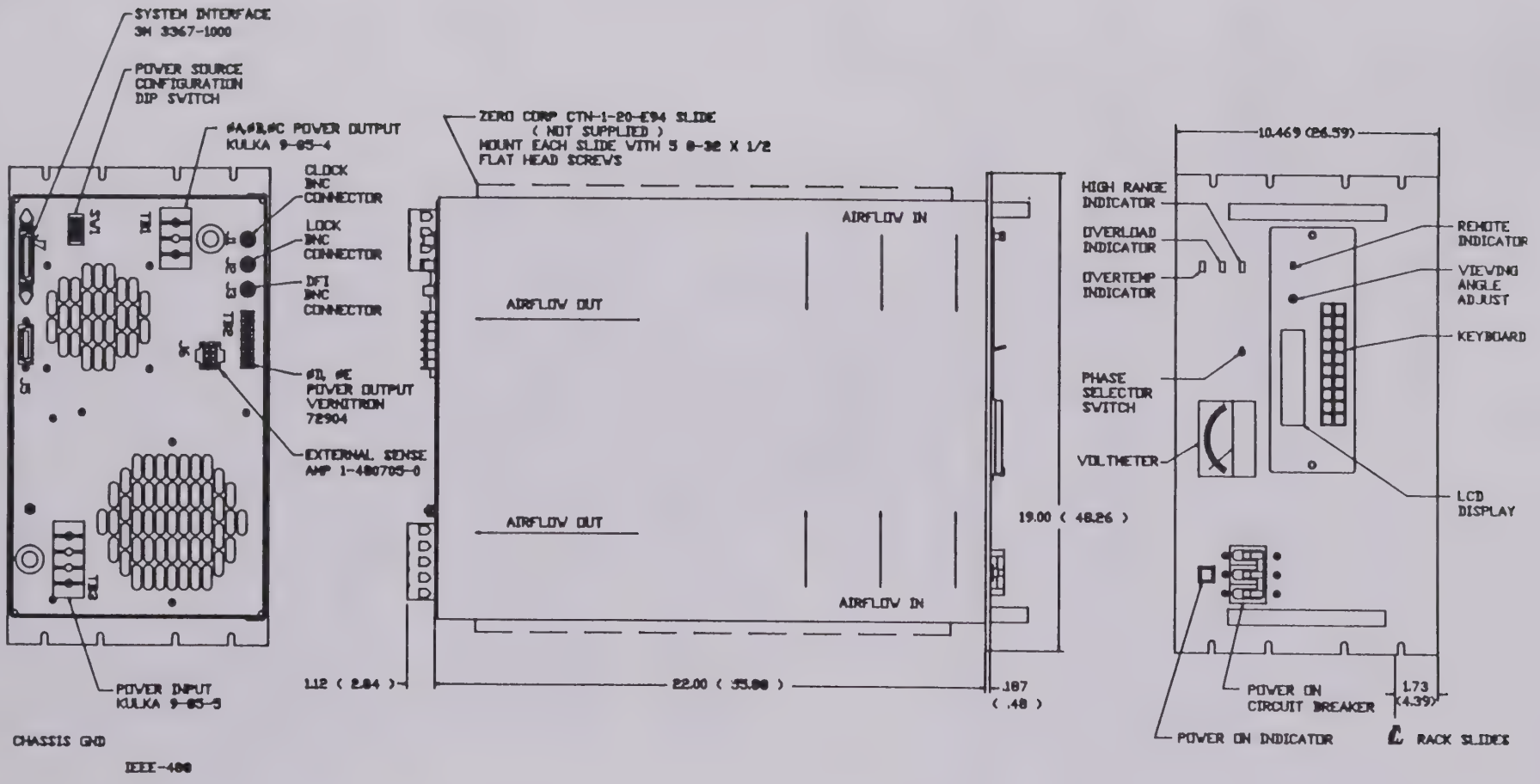


FIGURE 1-1

CALIFORNIA INSTRUMENTS 4500L/2750L

The 4500L-3P and 2750L-P will deliver full power from 45 to 5000 Hz. The 4500L and 2750L are illustrated in Figure 1-1. The 200/400 volt range (EHV Option) is specified for full power from 45 to 1000 Hz.

The output frequency of all "P" power systems can be programmed down to 17 Hz at a reduced output voltage.

1.3 ACCESSORY EQUIPMENT/RACK SLIDES

Zero Manufacturing Company Model CTN-1-20-E94 rack slides may be attached to the sides of the power source using 8-32 X 3/8 flat head screws.

1.4 SPECIFICATIONS

Table 1-1 contains the operation specifications of the AC Power System. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, constant line voltages and under no-load and with External Sense Lines connected unless specified otherwise.

TABLE 1-2

SPECIFICATIONS 4500L-P AND 2750L-P

(All specifications apply using external sense, 23 ±5°C, constant line and load conditions unless specified otherwise, after 30 minute warm-up.)

ELECTRICAL

OUTPUT SPECIFICATIONS

MODEL	VA (At full output voltage) TOTAL		VA (At full output voltage) PER PHASE		CURRENT PER PHASE VOLTAGE RANGE 135		CURRENT PER PHASE VOLTAGE RANGE 270	
	50°C	35°C	50°C	35°C	50°C	35°C	50°C	35°C
2750L-3	2700	3000	900	1000	6.66	7.40	3.30	3.70
2750L-1	2750	3000	2700	3000	20.0	22.22	10.00	11.11
4500L-3	4500	5000	1500	1667	11.12	12.34	5.56	6.17
4500L-1	4500	5000	4500	5000	33.34	37.04	16.67	18.52
9000L/2-3	9000	10000	3000	3333	22.24	24.68	11.12	12.34
9000L/2-1	9000	10000	9000	10000	66.66	74.08	33.33	37.04
13500L/3-3	13500	15000	4500	5000	33.34	37.04	16.67	18.52
13500L/3-1	13500	15000	13500	15000	100.0	111.2	50.0	55.6
27000L/6-3	27000	30000	9000	10000	66.66	74.08	33.33	37.04
27000L/6-1	27000	30000	27000	30000	200.0	222.2	100.0	111.1

NOTE: Increased current at 35°C is available up to 2000 Hz.

For other Voltage Ranges: Current per phase = VA (per phase)/Voltage Range

Power factor: 0 to unity at full rated output VA

Peak Repetitive Current: 2.5 times the maximum TRMS current at 50°C
2750L: 4 times TRMS current at 50°C

Peak Non-repetitive (10ms) Current: 2.7 times the maximum TRMS current at 50°C
2750L: 4 times TRMS current at 50°C

Voltage range: 135 and 270 (Standard)
67.5 and 135 (LV Option)
156 and 312 (HV Option)
200 and 400 (EHV Option)

OUTPUT SPECIFICATIONS (continued)

Total Distortion:
(Maximum for all harmonics and noise to 300 KHz at full power with linear load)

45 Hz to 2 KHz: 1% THD
to 5 KHz: 2% THD

Line regulation: ±0.02% of full scale for ±10% line change

Load regulation: ±0.05% of full scale from no load to full load

Voltage accuracy (no-load, 23°C, based on TRMS measurement, 45 to 5000 Hz values specified otherwise):

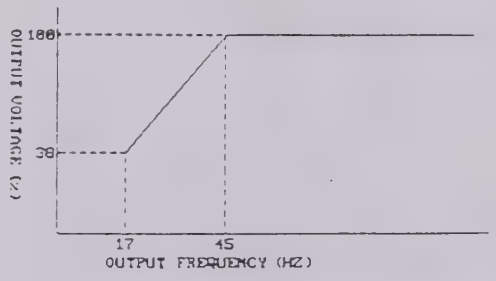
±0.135 volts from 5 to 135 volts
±0.54 volts from 135 to 312 volts
±1.5 volts from 5 to 200 volts (EHV Option), 45 to 1 KHz
±3.0 volts from 200 to 400 volts (EHV Option), 45 to 1 KHz

Add 2% of programmed value below 45 Hz.

Frequency Range:

At Full Scale Voltage
2750L-3, 4500L-3 45 Hz to 5000 Hz at 50°C maximum currents
All other models 45 Hz to 2000 Hz at 35°C maximum currents
EHV option 45 Hz to 1000 Hz

At less than Full Scale Voltage: (Refer to graph below)



Frequency accuracy: ±0.001% of programmed value

Frequency resolution: 0.01 Hz to 99.99
0.1 Hz to 999.9
1 Hz to 5000 Hz

Phase angle accuracy (With the same load on each phase):

Phase B and C relative to phase A: ±2 degrees to 2 KHz
±3 degrees to 5 KHz

PROTECTION

Output overload: Automatic default with output relays open when programming from 5.0 volts.

Output short circuit: Immediate default with no automatic recovery.

Input Overvoltage: Overvoltage causes the circuit breaker to trip.

Loss of Input phase: No output for loss of Phase B or C. Normal operation at reduced power with loss of Phase A.

Sense line fault: Immediate default of programmed output with relays open.

Temperature: Default of programmed output with relays open.

MEASUREMENTS (at 23°C)

Voltage accuracy: ±10 Digits of resolution

Voltage resolution: 0.1 volt for 1 digit

	MODEL	
	2750L-3P 2750L-1P-EHV, 4500L-3P	All Other Models
Current accuracy:	±10 Digits of resolution	
Current resolution:	0.01 Amp	0.1 Amp For 1 digit
True power accuracy:	±10 Digits of resolution	
True power resolution:	1 Watt	0.01 Kw For 1 digit
Apparent power resolution:	1 VA	0.01 KVA For 1 digit
Power factor resolution:	.001 For 1 digit	

Frequency	ACCURACY (Hz)	RESOLUTION (Hz)
45 to 99.99 Hz	±0.02	0.01
100 to 499.9 Hz	±0.2	0.1
500 to 999.9 Hz	±0.5	0.1
1000 to 5000 Hz	±10	1

NOTE: For frequencies below 45 Hz, add 2% of measured value to measurement accuracy specification.

Phase angle accuracy: ±2.0 degrees to 2 KHz, ±3 degrees to 5 KHz

Phase angle resolution: 0.1 degree

SUPPLEMENTAL SPECIFICATIONS

LINE INPUT

Voltage: 187 to 252V_{L-L} three-phase

2750L: Same as above except can also operate with 1-phase input with 187 to 252 volts.

UP Option: 342 to 456V_{L-L} three-phase

Current (PF=.6, EFF=75%, V line=187, 3ø, full load): 31 Amps
2750L-3ø: 19 Amps
2750L-1ø: 29 Amps

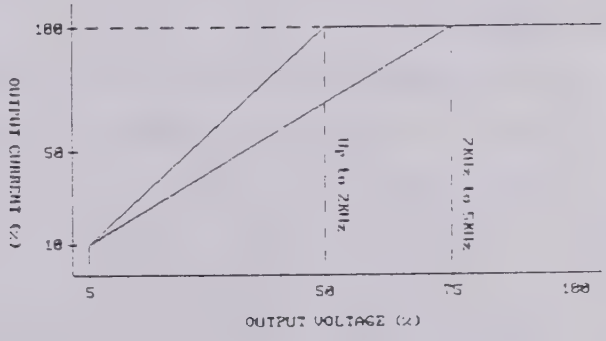
Frequency: 47 to 440 Hz

Efficiency: 75% (typical)

Surge Current:
(turn-on, V_{L-L} = 252): 178 Amps

SUPPLEMENTAL OUTPUT SPECIFICATIONS

Full current range:



Output noise voltage (20 KHz to 1 MHz at full-load):
200 millivolts (typical)

Voltage temperature coefficient: ±0.02 volts per °C

Voltage stability (24 hours, at constant line, load and temp.):

±0.015% of full scale

Voltage Settling Time: (from start of voltage change from 5.0 VRMS or higher voltage to a higher voltage to within 2% of final value.)

No-load: 16 milliseconds
Full-load: 0.3 seconds (16 milliseconds to within 15% of final value)

SUPPLEMENTAL SPECIFICATIONS (continued)

Steady-State Output Impedance (ohms)

= (voltage range) x (0.0005)/Full-load current

Frequency Temperature Coefficient: ±5 ppm of value per °C

Frequency Stability: ±15 ppm of value per year

Isolation: Line input to output: >500 VRMS

Front panel controls:

Power On/Off circuit breaker

Keypad: 20-key keyboard

Analog Meter Phase Selection Switch

Bus: IEEE-488 (GPIB)

Subsets; SH1, AH1, T6, L3, SR1, RL2, DC1, DT1

Codes and Formats:

Numeric Representation: NR1, NR2 or NR3

Header: HR1 or HR2 (upper or lower case)

Message Separators: SR1

Data transfer rate: 200K bytes per second

Language: A California Instruments language which is upward compatible from other C.I. products

SUPPLEMENTAL SPECIFICATIONS (continued)

Functions	Range	Resolution	Initialization
[1]Voltage	0 to range	0.1	5.0
Voltage range	135/270	0.1	135
[1]Phase angle	0 to 999.9	0.1	B = 240 C = 120
Output relay (GPIB only)	Open or Close		Open
External Sync	Internal or External		Internal
Storage Registers	Registers 0 through 16		

Frequency

Range: 45 to 5000 Hz for 4500L-3P & 2750L-3P
2000 Hz for all others

Resolution: 0.01 Hz from 45.00 to 99.99 Hz
0.1 Hz from 100.0 to 999.9 Hz
1 Hz from 1000 to 5000 Hz

Default: 60 Hz (any other available)

[1]Current Limit

MODEL	CURRENT LIMIT RANGE VOLTAGE RANGE 135	270	RESOLUTION	DEFAULT* (on 135 Range)
2750L-3P	0 to 7.40,	3.70	0.01	7.40
2750L-1P	0 to 22.22,	11.11	0.01	22.22
4500L-3P	0 to 12.34,	6.17	0.01	12.34
4500L-1P	0 to 37.04,	18.52	0.01	37.04
9000L/2-3P	0 to 24.68,	12.34	0.01	24.68
9000L/2-1P	0 to 74.08,	37.04	0.01	74.08
13500L/3-3P	0 to 37.04,	18.52	0.01	37.04
13500L/3-1P	0 to 111.2,	55.6	0.1	111.2
27000L/6-3P	0 to 74.08,	37.04	0.01	74.08
27000L/6-1P	0 to 222.2,	111.1	0.1	222.2

For other Voltage Ranges: Current Limit Range =
(VA per phase)/Voltage Range

Accuracy: -0 to +15% of programmed value

NOTE: [1]Independent control for each output phase

NOTE (*) Customer access to Initial/Default values for:

Frequency, Voltage, Voltage Range and Current Limit

SUPPLEMENTAL SPECIFICATIONS (continued)

OTHER PROGRAMMABLE FUNCTIONS

Register linking

Calibration of Phase, Output Voltage and measurement functions.

Ramp/Sweeps of Voltage, Frequency, Phase and Current Limit up to 2 functions simultaneously.

Service request (GPIB): Service Request for output faults, syntax errors and end of measurement.

Group execute trigger (GPIB): Trigger setups and terminate programs.

Status reporting: Serial Poll Status Byte and error messages.

Remote Shutdown — A logic low input will program the voltage to 0 and open the Output Relays.

Output Relay: Controlled by GPIB. Normally open at power-up. Closed when the first function is programmed from the front panel keypad.

External sense: Compensates for up to a 10% drop in the load lines.

Function Strobe Output: A 400 uS logic low output when any output is programmed.

External Sync: A 5 volt, 45 to 5 KHz, 5 milliamp TTL input. The output will track the frequency and phase of this input. Loss of this input will cause the output to default.

Indicators: 32 character LCD display, Output Overload, Overtemperature Power On, High Voltage Range.

Dimensions: 10.5 inches (26.7 cm) high, 23 inches (58.4 cm) deep and 19 inches (48.3 cm) wide.

Weight lbs (Kg): 175 (79.2)

Material: Aluminum for Front panel, rear panel and top cover. Steel for chassis.

Finish:

Front panel - painted gray 26440 per Federal Standard 595
Chassis - zinc plate type 2 class 2.
Rear panel and top cover - iridite.

SUPPLEMENTAL SPECIFICATIONS (continued)

Air intake/exhaust: Intake from both sides of chassis.
Exhaust to the rear.

Modularity: Oscillator, All amplifiers, DC power supplies, Current Limit Board Assembly, Range-Relay Board, All displays

Connectors

Input Power: Kulka terminal block, 9-85-5 (TB3)

Output Power: Kulka terminal block, 9-85-4 (TB1)

Auxiliary Output Power: Barrier Strip (TB2)

External Sense: AMP connector, 1-480705-0 (J6)

System Interface
(mating connector): 3M Connector 3366-1001 plug

System Interface: 3M connector, 3367-1000 (J7)

IEEE-488 connector: J5

Chassis slides: Zero Manufacturing Company Model CTN-1-20-E94

Operating temperature: 0°C to 50°C

Storage temperature: -40°C to +85°C

Operating altitude: 0 to 6000 Ft.

OPTIONS SPECIFICATIONS

Universal Input Power (UP option): 342 to 456 V_{L-L} three phase

Output Voltage Ranges: 156/312 (HV option)
67.5/135 (LV option)
200.0/400.0 (EHV option)

Master: Must be used with LK option

Slave: Must be used with LK option

Square Wave (4500L-3P and 2750L-3P only) Performance from 50 Hz to 5 KHz:

Rise and Fall Time (10% to 90%): Less than 40 microseconds

Droop: Less than 10%

Overshoot (resistive load): Less than 20%

OPTIONS SPECIFICATIONS (continued)

Mode: Allows power system to be programmed to a 1 or 3 phase output.

Auxiliary outputs (Option AX): Master and Slave options not available with this option

(All specifications at 23°C and verified with TRMS voltmeter. The Phase D sense lines must be connected to the Phase D output.)

Phase D:

Voltage: 26.0 Vrms fixed

Accuracy: ±2%

Current: 3.0 Amps (Max)

Frequency: 360 to 440 (Tracks the main outputs)

Phase: Tracks the Phase A output

Accuracy: ±1 degree. (All outputs at half load, 400 Hz)

Distortion: 1% THD maximum with linear load

Line Regulation: ±0.05% using external sense

Load Regulation: ±0.05% using external sense

Phase E

Voltage: 5.0 Vrms fixed

Accuracy: ±5%

Current: 5.0 Amps (Max)

Frequency: 360 to 440 Hz (Tracks the main outputs)

Phase: Tracks the phase A output with Phase D

Distortion: 1% THD maximum with linear load

Line Regulation: ±0.1% for 10% line change

Load Regulation: ±10% from no-load to full-load

OPTIONS SPECIFICATIONS (continued)

MATE (MT option)

CIIL language

DFI connector

Confidence Test (Tests 3 phases for output, oscillator drive, phase relationship, frequency and current limit.)

MIL-704D (704D option)

Performs all sections of MIL-STD-704D

2-PHASE (2P): 2-phase operation

SYSTEMS

MODEL	POWER PER PHASE (35°C)	MAX CURRENT PER PHASE (135V RANGE) (35°C)
9000L-1P	10000	74.08
13500L-1P	15000	111.2
27000L-1P	30000	222.2
9000L-2P	5000	37.04
9000L-3P	3333	24.68
13500L-3P	5000	37.04
27000L-3P	10000	74.08

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.2 POWER REQUIREMENTS

The AC Power System has been designed to operate from a three-phase AC line voltage. The input line voltage may be between 187 volts and 252 volts line-to-line for the standard product or 342 to 456 volts line-to-line for the UP option. The frequency may be between 47 Hz and 440 Hz. Select an AC input line and hookup wire to the AC Power System that will deliver 20 amps per phase and still supply a minimum of 187 volts line-to-line. Refer to Figure 2-2 for circuit breaker requirements of all multichassis power system.

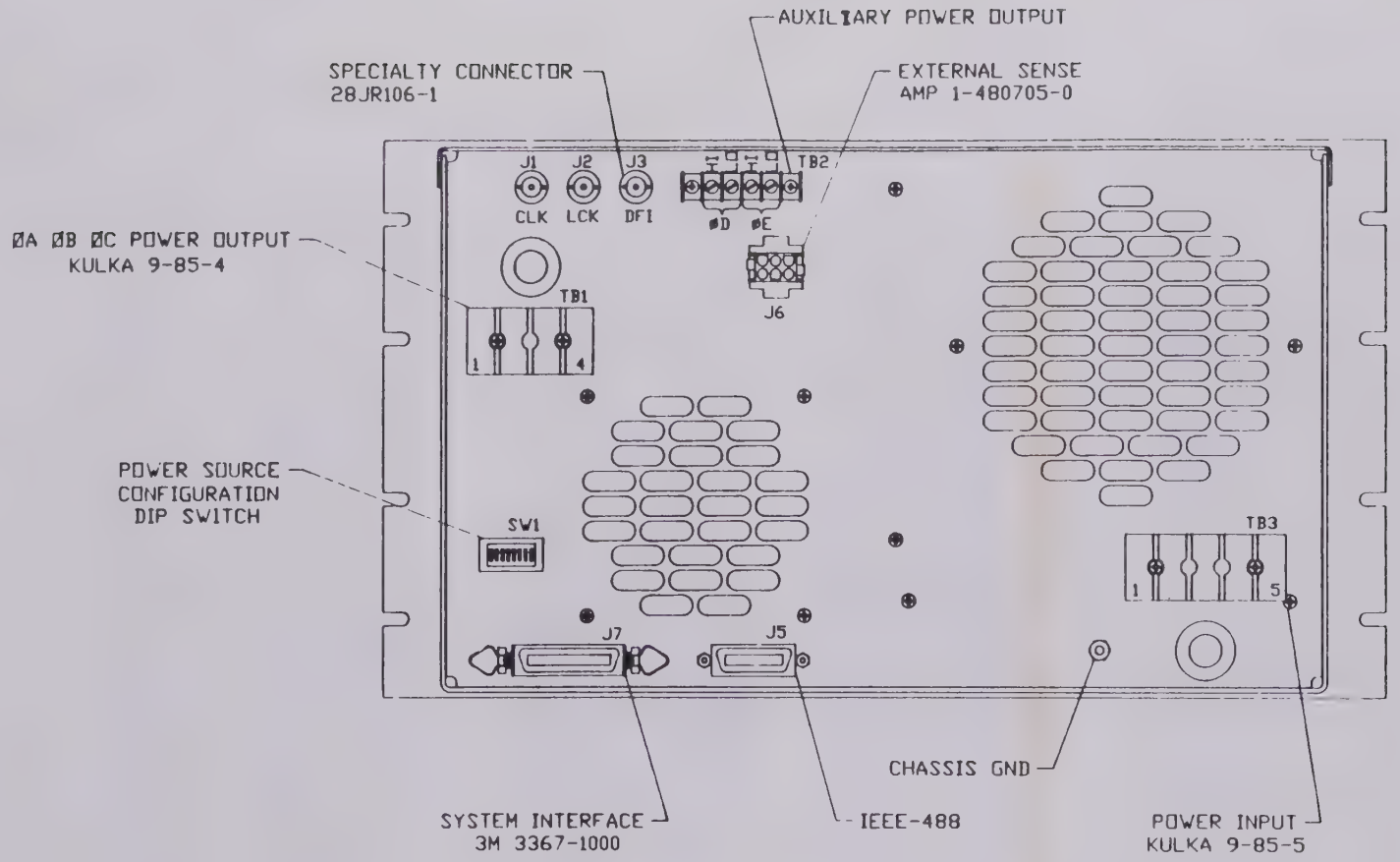
2.3 MECHANICAL INSTALLATION

The power system has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in paragraph 1.3. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 1-1.

2.4 INPUT WIRING

The AC Power System must be operated from a three-wire three-phase service with a fourth wire for common. The common wire is connected to the chassis of the AC Power System. The mains source must have a current rating greater than or equal to the AC Power System circuit breaker, 20 amps. Refer to Figure 2-1 for the input power connections. Refer to Figure 2-2 for all multichassis power systems.

The 2750L may also be operated from a 1-phase input. The 1-phase line input must be connected between the øB and øC terminals of TB3 on the rear panel. These terminals are identified as terminals 2 and 3 of TB3 in Figure 2-1.



TB3

PIN	FUNCTION
1	3 PHASE INPUT
2	
3	
5	GROUND

TB1

PIN	FUNCTION
1	C OUTPUT
2	B OUTPUT
3	A OUTPUT
4	NEUTRAL

J6

PIN	FUNCTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE
5	D SENSE HI
6	D SENSE LO

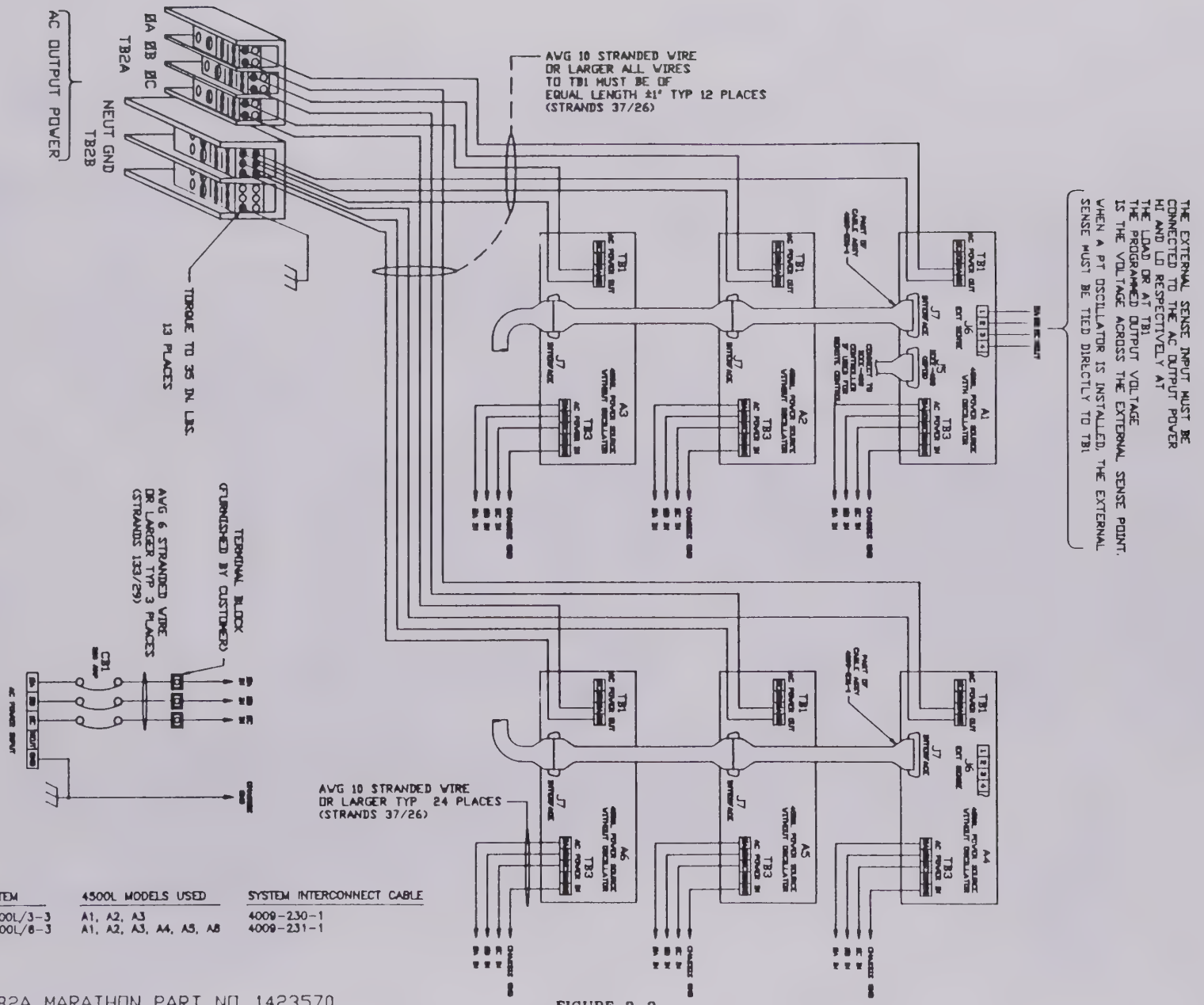
FIGURE 2-1
2750L/4500I REAR PANEL CONNECTIONS

THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB1
THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.
WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB1
AWG 10 STRANDED WIRE OR LARGER ALL WIRES TO TB1 MUST BE OF EQUAL LENGTH ±1" (STRANDS 37/26)
TB1 AC POWER OUT
A1
TB3 AC POWER IN
J7 INTERFACE
J5
A2
A3
A4
TERMINAL BLOCK (FURNISHED BY CUSTOMER)
TORQUE TO 35 IN. LBS. 17 PLACES
AWG 10 STRANDED WIRE OR LARGER TYP 12 PLACES (STRANDS 37/26)
AWG 8 STRANDED WIRE OR LARGER, TYP 3 PLACES (STRANDS 133/29)
ØA ØB ØC NEUT GND
TB2A TB2B
AC OUTPUT POWER
AC POWER INPUT

SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
4500L-3	A1	NONE
9000L/2-3	A1, A2	4009-230-1
18000L/4-3	A1, A2, A3, A4	4009-231-1

1. TB2A MARATHON PART NUMBER 1423570.
TB2B MARATHON PART NUMBER 1422570.
(SHIPPED WITH POWER SOURCE SYSTEM)

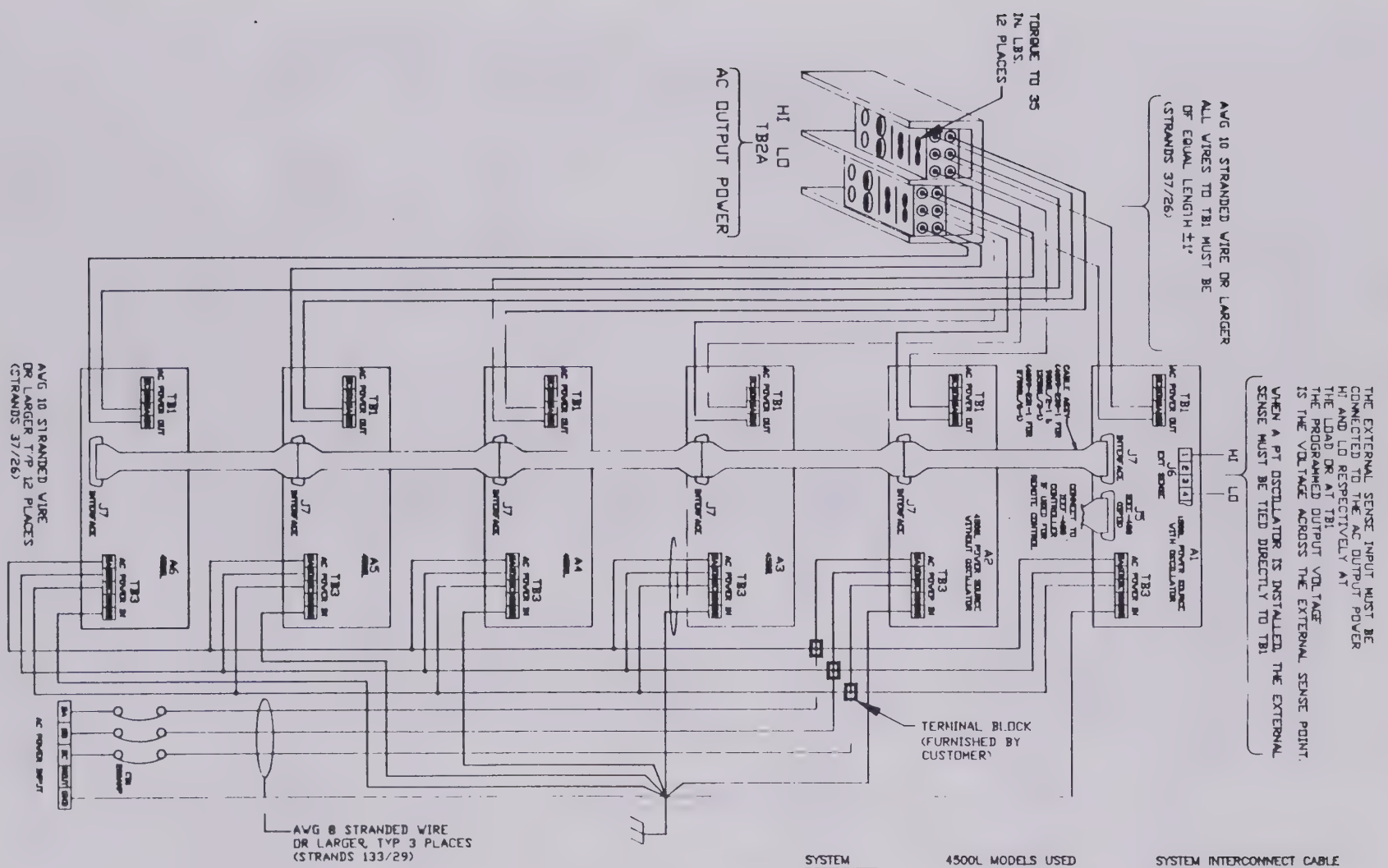
FIGURE 2-2
SYSTEM INTERCONNECT
2750L-3, 4600L-3, 9000L/2-3, 18000L/4-3



SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
13500L/3-3	A1, A2, A3	4009-230-1
27000L/6-3	A1, A2, A3, A4, A5, A6	4009-231-1

1. TB2A MARATHON PART NO. 1423570,
TB2B MARATHON PART NO. 1432555.
(SHIPPED WITH POWER SOURCE SYSTEM)

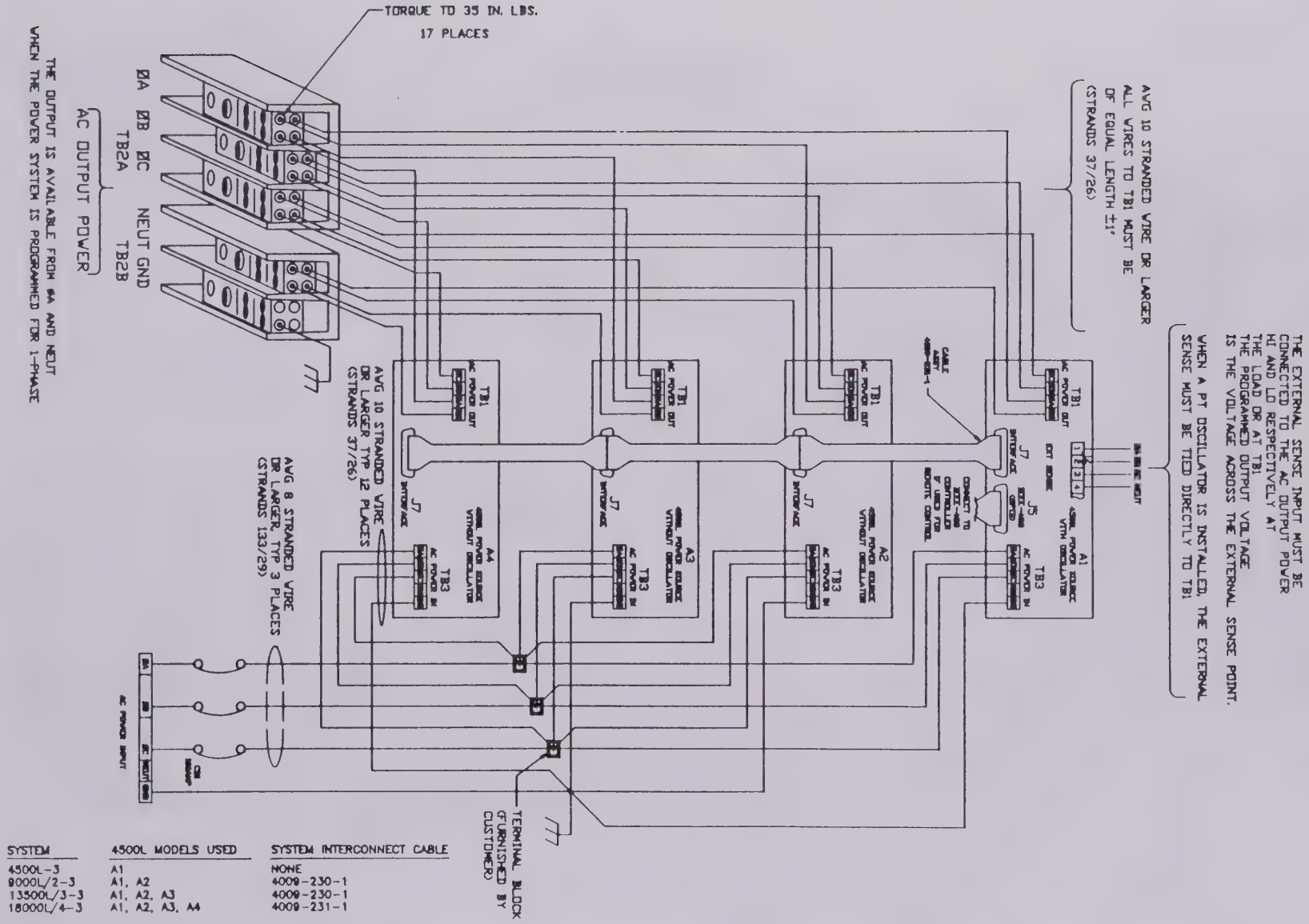
FIGURE 2-2
SYSTEM INTERCONNECT
13500L/3-3, 27000L/6-3, 9000L/2-2 (No A2, A5)


TORQUE TO 35 IN LBS. 12 PLACES
HI LO TB2A
AC OUTPUT POWER
AWG 10 STRANDED WIRE OR LARGER ALL WIRES TO TB1 MUST BE OF EQUAL LENGTH ±1" (STRANDS 37/26)
THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB1. THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT. WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB1.
HI
LO
AWG 10 STRANDED WIRE OR LARGER, TYP 12 PLACES (STRANDS 37/26)
TERMINAL BLOCK (FURNISHED BY CUSTOMER)
AWG 8 STRANDED WIRE OR LARGER, TYP 3 PLACES (STRANDS 133/29)

SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
4500L-1	A1	NONE
9000L/2-1	A1, A2	4009-230-1
13500L/3-1	A1, A2, A3	4009-230-1
27000L/6-1	A1, A2, A3, A4, A5, A6	4009-231-1

3. FOR 9000L/2-1 & 13500L/3-1 USE 100 AMP CB1. NO CB1 FOR 4500L-1
2. TB2A (9000L/2-1 & 13500L/3-1) MARATHON PART NUMBER 1422570. TB2A (27000L/6-1) MARATHON PART NUMBER 1432555. (SHIPPED WITH POWER SOURCE SYSTEM) NO TB1 FOR 4500L-1
1. SYSTEM INTERCONNECT SHOWN FOR 27000L/6-1 SYSTEM. FOR 13500L/3-1 SYSTEM ELIMINATE POWER SOURCES A4, A5 & A6. FOR 9000L/2-1 SYSTEM ELIMINATE POWER SOURCE A3 ONE CONNECTOR OF CABLE ASSY 4009-230-1 IS NOT TERMINATED FOR 9000L/2-1

FIGURE 2-2
SYSTEM INTERCONNECT
FOR ALL 1-PHASE SYSTEMS


TORQUE TO 35 IN. LBS.
17 PLACES
ØA ØB ØC NEUT GND
TB2A TB2B
AC OUTPUT POWER
THE OUTPUT IS AVAILABLE FROM ØA AND NEUT WHEN THE POWER SYSTEM IS PROGRAMMED FOR 1-PHASE
AVG 10 STRANDED WIRE OR LARGER ALL WIRES TO TB1 MUST BE OF EQUAL LENGTH ±1" (STRANDS 37/26)
THE EXTERNAL SENSE INPUT MUST BE CONNECTED TO THE AC OUTPUT POWER HI AND LO RESPECTIVELY AT THE LOAD OR AT TB1. THE PROGRAMMED OUTPUT VOLTAGE IS THE VOLTAGE ACROSS THE EXTERNAL SENSE POINT.
WHEN A PT OSCILLATOR IS INSTALLED, THE EXTERNAL SENSE MUST BE TIED DIRECTLY TO TB1
AVG 10 STRANDED WIRE OR LARGER (STRANDS 37/26)
AVG 8 STRANDED WIRE OR LARGER, TYP 3 PLACES (STRANDS 133/29)
TERMINAL BLOCK (FURNISHED BY CUSTOMER)
TB1
TB2
TB3
J7
J5
A1
A2
A3
A4

SYSTEM	4500L MODELS USED	SYSTEM INTERCONNECT CABLE
4500L-3	A1	NONE
9000L/2-3	A1, A2	4009-230-1
13500L/3-3	A1, A2, A3	4009-230-1
18000L/4-3	A1, A2, A3, A4	4009-231-1

1. TB2A MARATHON PART NUMBER 1423570, TB2B MARATHON PART NUMBER 1422570. (SHIPPED WITH POWER SOURCE SYSTEM)

FIGURE 2-2
SYSTEM INTERCONNECT FOR MODE OPTION
2750L-3, 4500L-3, 9000L/2-3, 13500L/3-3, 18000L/4-3

2.5 OUTPUT CONNECTIONS

The output terminal block, TB1, is located at the rear of the power system. For a single power source power system, all load connections must be made at TB1. The external sense inputs allow the power system output voltages to be monitored directly at the load and must be connected. The external sense wires are connected at J6 on the rear panel. Refer to Figure 2-2 for all connections.

The output power cables must be large enough to prevent a voltage difference greater than 2 VRMS between the voltage at TB1 and the voltage between External Sense HI and LO input. Table 2-1 shows the maximum length of the output wires. The table assumes the External Sense input is connected at the load.

TABLE 2-1

MAXIMUM LENGTH OF OUTPUT WIRES

WIRE GAGE (AWG)	MAXIMUM LENGTH (ft) OF WIRE BETWEEN OUTPUT (HI) AND LOAD
14	MAX LENGTH (ft) = 2/(MAX CURRENT PER PHASE X 0.0027)
12	MAX LENGTH (ft) = 2/(MAX CURRENT PER PHASE X 0.0017)
10	MAX LENGTH (ft) = 2/(MAX CURRENT PER PHASE X 0.00111)
8	MAX LENGTH (ft) = 2/(MAX CURRENT PER PHASE X 0.00061)

For a single power source, 1-phase power system the output power is available on TB1, pins 3 and 4.

The External Sense inputs must be connected or an AMP FAULT error message will be shown on the display and reported through the external interface.

Refer to Figure 2-2 for all multiple power source power system hook-ups.

NOTE: A special hook-up is required for all multiple power source power systems with the MODE Option. Refer to Figure 2-2 for the connections. The 1-phase output for a single power source with the MODE Option is available from TB1, pins 3 and 4.

2.6 OUTPUT VOLTAGE RANGES

The standard voltage ranges for this AC power system are 135 and 270. Selection of the 270 volt range causes the front panel "HIGH RANGE" lamp to illuminate. The range may be changed from either the front panel keypad or through the GPIB input. All voltages are programmed line-to-neutral for 3-phase operation.

2.7 FUNCTION TEST

Refer to Figure 2-3 for the test setup.

Perform the following test sequence.

1) Apply the AC line power and turn on the front panel circuit breaker. No loads should be connected to the output terminal block.

2) Verify that the POWER ON lamp is lit.

3) With the front panel keypad program the HI output voltage range with the following key sequences:

   4 ENT To select the Range screen (RNG)

   To program the HI range (ex., 270 volt range):

   270 PRG ENT

4) Verify the HIGH RANGE lamp is lit.

5) Program the output to maximum voltage with the following key sequences:

   Depress the MON key 1 time to select the Amplitude screen (AMP).

   To program the voltage to maximum.

   (Maximum Range value) PRG ENT

6) Verify that the front panel voltmeter indicates approximately the programmed value for all three phases or for phase A for a 1-phase system.

7) Program the AC Power System to the low range with the following keystrokes:

   4 ENT (low voltage range value) PRG ENT

8) Program the output to the maximum low voltage range voltage:

5 ENT (maximum low voltage range value) PRG ENT

9) Observe each of the outputs with the oscilloscope or distortion analyzer. The outputs should be clean sine waves having less than 1.0% distortion.

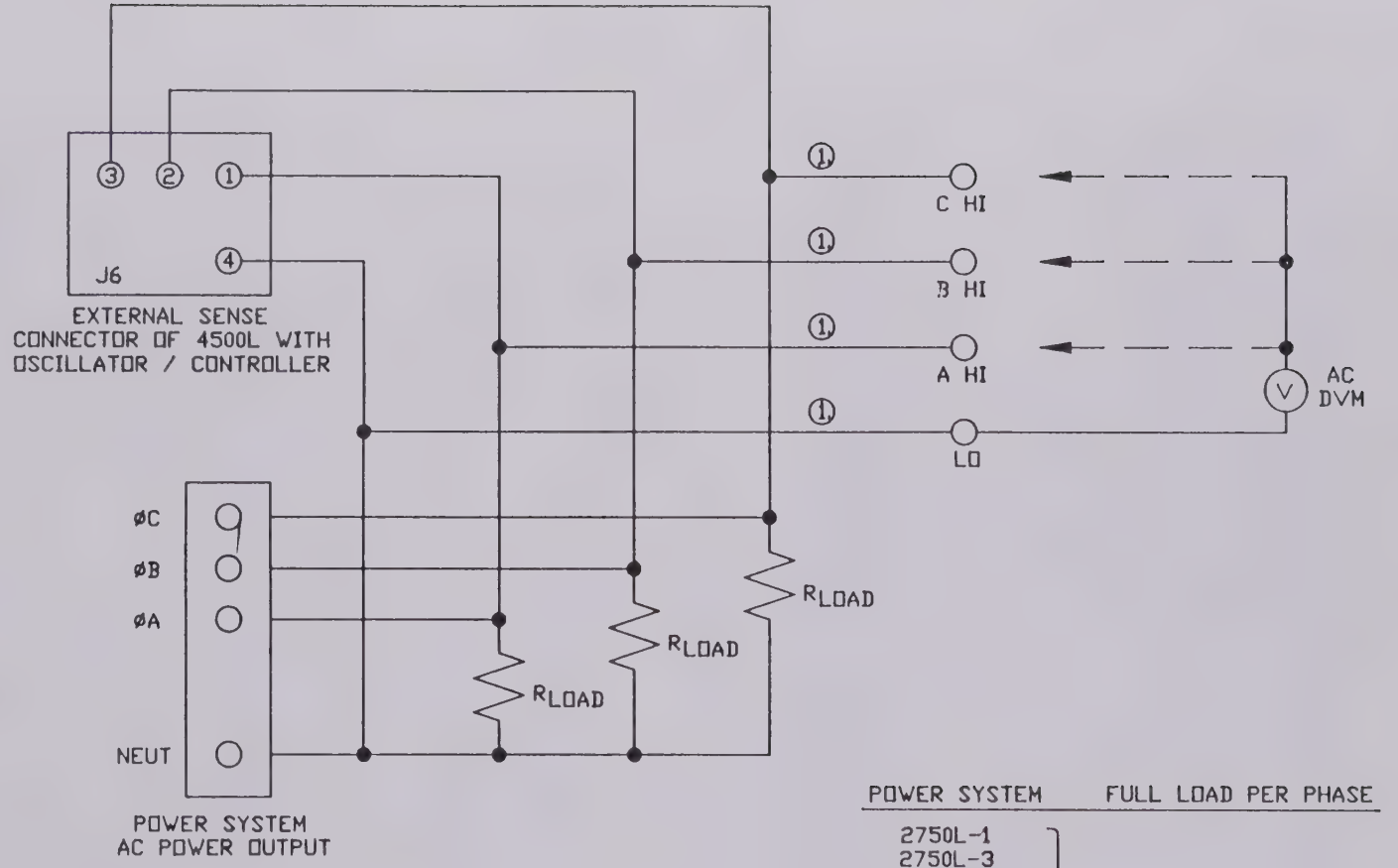
10) Apply full loads to each phase (Refer to Table 4-1). Verify that the voltage of each phase remains within (0.0005 x voltage range) volts of the no-load voltage. The waveforms shall still appear clean on the oscilloscope and have less than 1% distortion.

11) Program the Current Limit to 5.0 amps:

    8 ENT

    5 PRG ENT

12) The display should show the error message 'AMP ABC FAULT' for a 3-phase system. The error message may not, however, include all of the phases. The output will default to a programmed value of 5.0 volts with the output relays open.



POWER SYSTEM	FULL LOAD PER PHASE
2750L-1	REFER TO LOAD RES VALUE FROM TABLE 4-1
2750L-3	
4500L-3	
4500L-1	
9000L/2-3	
9000L/2-1	
13500L/3-3	
13500L/3-1	
27000L/6-3	
27000L/6-1	

① NOTE: AC DVM MUST BE CONNECTED TO SENSE LINES INSTEAD OF CURRENT CARRYING WIRES.

FIGURE 2-3
FUNCTION TEST SETUP

SECTION 3

OPERATION

3.1 GENERAL

The AC Power System may be programmed from the front panel or through the IEEE-488 external interface. The rear panel of the AC Power System holds the power input and output terminals external sense connector, system interface connector, IEEE-488 interface connector and the chassis ground stud.

3.2 FRONT PANEL CONTROLS

All front panel controls are shown in Figure 3-1. A voltmeter selector switch is located at the right side of the front panel voltmeter. The three position switch changes the signal applied to the voltmeter from the three output phases.

A three-pole circuit breaker is on the left side of the front panel. The circuit breaker is used to switch power to the unit. When the circuit breaker is switched ON, the amber indicator lamp above the circuit breaker illuminates.

The front panel has a subpanel with a keypad, remote lamp, LCD display and a viewing angle adjustment. The 20-key keypad allows the power source to be manually programmed at the front panel. The knob labeled VIEW ANGLE may be turned to adjust the contrast of the front panel display. The remote lamp illuminates when the AC Power System has been addressed through the IEEE-488 interface (GPIB).

3.3 FRONT PANEL INDICATORS

A lamp is located just above the input circuit breaker. It illuminates when power is applied and the circuit breaker is on.

An analog voltmeter, that indicates from 0 to 300 volts, shows the actual voltage of the phase A, B and C outputs. The phase is determined by a three position toggle switch at the right side of the meter.

An OVERTEMP lamp illuminates when the temperature of the power amplifier heatsinks has surpassed a maximum set level. When the fault is detected, the outputs are disabled and must be reprogrammed after the overtemperature condition has been eliminated.

An OVERLOAD lamp illuminates when the output current exceeds the programmed current limit value. The outputs will default to 0.0 volts and the output relays will open shortly after the condition occurs.

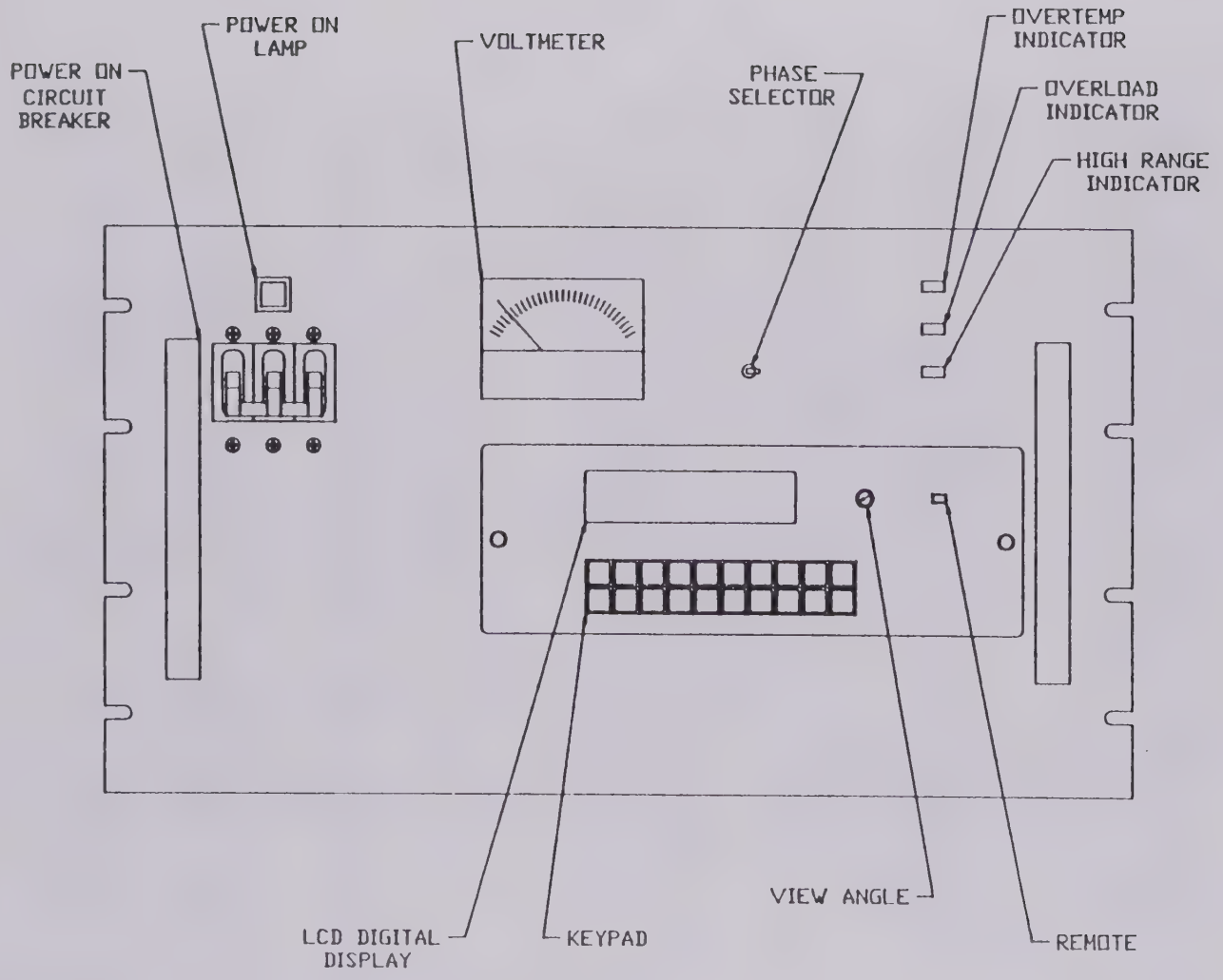


FIGURE 3-1
FRONT PANEL CONTROLS AND INDICATORS

A HIGH RANGE lamp illuminates when the AC Power System is programmed to the high voltage range.

An LCD digital display shows the numeric value of all programmed output parameters. It also shows all error messages and measured values.

A REMOTE lamp illuminates when the AC Power System has been addressed from the IEEE-488 interface.

3.4 REAR PANEL CONNECTIONS

(Refer to Figure 3-2 for all rear panel connections.)

3.4.1 POWER INPUT

TB3 is the terminal block for the 3-phase input voltage. Terminals 1, 2 and 3 connect to each leg of the 3-phase input. Terminal 5 is the chassis connection which should be connected to the input mains ground.

3.4.2 POWER OUTPUT

TB1 is the power output terminal block. Refer to Table 3-1 for identification of the TB1 terminals. Terminal 3 and 4 are used for a 1-phase system. Refer to Figure 2-2 for the output of all multiple power source power systems.

TB1	DESCRIPTION
1	Phase C Output HI
2	Phase B Output HI
3	Phase A Output HI
4	Output Neutral

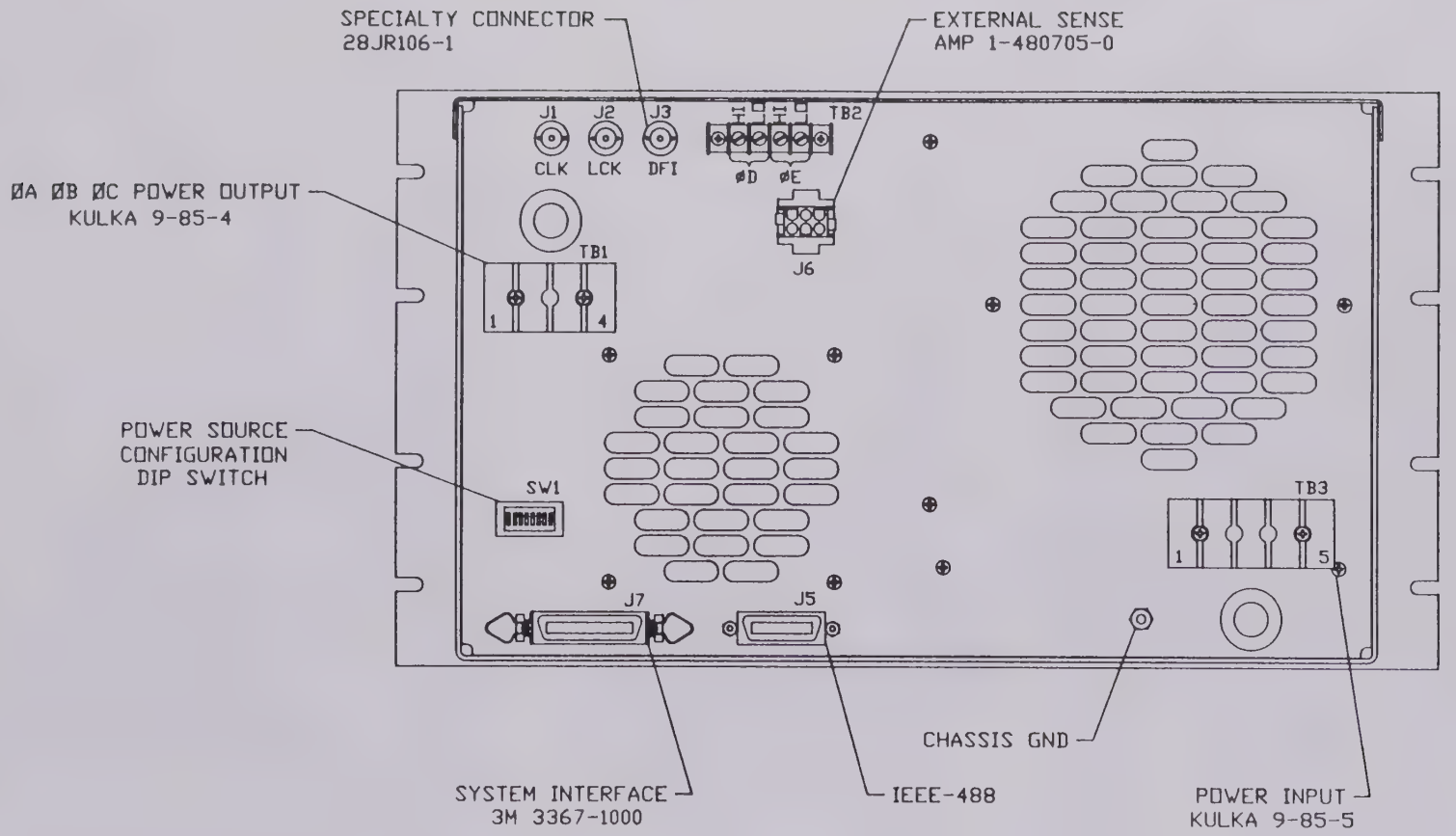
TABLE 3-1

3.4.3 EXTERNAL SENSE

J6 is the external sense input connector. The external sense input of the master 4500L must be connected to the respective AC Power System output. If the inputs are not connected, an AMP FAULT error message will be generated. Table 3-2 identifies the pins of connector J6.

J6	DESCRIPTION	
1	Phase A Sense HI	Phase A Output HI
2	Phase B Sense HI	Phase B Output HI
3	Phase C Sense HI	Phase C Output HI
4	Neutral Sense	Neutral Output
5	Phase D sense HI	Phase D Output HI
6	Phase D sense LO	Phase D Output LO

TABLE 3-2



TB3

PIN	FUNCTION
1	3 PHASE INPUT
2	
3	
5	GROUND

TB1

PIN	FUNCTION
1	C OUTPUT
2	B OUTPUT
3	A OUTPUT
4	NEUTRAL

J6

PIN	FUNCTION
1	A SENSE
2	B SENSE
3	C SENSE
4	NEUT SENSE
5	D SENSE HI
6	D SENSE LO

FIGURE 3-2
2750L/4500L REAR PANEL CONNECTIONS

3.4.4 IEEE-488 CONNECTOR

J5 is the IEEE-488 (GPIB) connector for the master 4500L or the 2750L only.

3.4.5 SYSTEM INTERFACE

J7 is the System Interface connector. Table 3-3 identifies the pins of the System Interface connector.

J7	Description
1	Analog Common
2	MR B, Phase B amplifier input signal
3	Analog Common
4	CS B, Phase B current sum
5	CT Common, Current Transformer Common
6	OS B, Oscillator Phase B output
7	Analog Common
8	CL B, Phase B DC current limit
9	RPV, Not used
10	$\overline{\text{OVR TEMP}}$, Overtemperature indication
11	$\overline{\text{CNF}}$, Output relay
12	FLT C, Phase C current limit fault
13	FLT A, Phase A current limit fault
14	F STB LO, Function Sync output LO
15	EX SYNC LO, External Sync input LO
16	No connection
17	No connection
18	No connection
19	MR C, Phase C amplifier input signal
20	MR A, Phase A amplifier input signal
21	CS C, Phase C current sum
22	CS A, Phase A current sum
23	OS C, Oscillator Phase C output
24	OS A, Oscillator Phase A output
25	CL C, Phase C DC current limit
26	CL A, Phase A DC current limit
27	D COM, Digital Common
28	$\overline{\text{RNG HI}}$, High Voltage range
29	
30	FLT B, Phase B current limit fault
31	F STB HI. Function Sync output HI
32	EX SYNC HI, External Sync input HI
36	REMOTE SHUTDOWN

TABLE 3-3

SYSTEM INTERFACE CONNECTOR (J7)

J7-1 ANALOG COMMON: This is the common for all analog signals on the connector.

J7-2 MR B: This is the input signal to the phase B amplifier from the internal oscillator drive signal. Make no connection to this pin except for troubleshooting.

J7-3 ANALOG COMMON: See J7-1.

J7-4 CS B: Current sum for the phase B output. Make no connections to the pin.

J7-5 CT COMMON:

J7-6 OS B: This is the output from the internal phase B oscillator. Use this pin as an input if an oscillator is not installed. A 5.0 VRMS signal will generate a full-scale output voltage.

J7-7 ANALOG COMMON: See J7-1.

J7-8 CL B: A DC level from the oscillator used to set the current limit for phase B.

J7-9 RPV: This input is used for an optional Remote program of the output. With this option the output voltage may be controlled with a DC voltage.

J7-10 $\overline{\text{OVR TEMP}}$: A logic low output to indicate an overtemperature condition. Make no condition to the pin.

J7-11 $\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open. make no connection to the pin.

J7-12 FLT C: Make no connections.

J7-13 FLT A: Make no connections.

J7-14 F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.

J7-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J7-32.

J7-16 No connection.
J7-17 No connection.

J7-18 No connection.

J7-19 MR C: This is the input signal to the phase C amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J7-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J7-21 CS C: Current sum for the phase C output. Make no connection to this pin.

J7-22 CS A: Current sum for the phase A output. Make no connection to this pin.

J7-23 OS C: This is the output from the internal phase C oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.

J7-24 OS A: This is the output from the internal phase A oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.

J7-25 CL C: A DC level from the oscillator used to set the current limit for phase C. Make no connection to this pin.

J7-26 CL A: A DC level from the oscillator used to set the current limit for phase A. Make no connection to this pin.

J7-27 D COM: Digital common.

J7-28 $\overline{\text{RNG HI}}$: A logic output from the internal oscillator to control the range relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.

J7-29 Make no connection.

J7-30 FLT B: Make no connection.

J7-31 F STB HI: Function Sync High signal. This is the collector lead of an optically isolated NON transistor. The internal power controller turns this transistor on to indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (<.4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC must be connected to J7, pin 31. J7, pin 14, is the common output. Refer to Figure 3-3.

J7-32 EX SYNC HI: External Sync Low signal. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 5 ma. The input should have a duty cycle 50 ±30%. J7-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

J7-36 REMOTE SHUTDOWN: This is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0.0 volts and the output relays to open. A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J7-27 (D COM) will simulate a logic low state.

3.4.6 AUXILIARY OUTPUT (AX Option)

TB2 is the terminal block for the optional Auxiliary outputs. The Auxiliary outputs are fixed 26V rms, Phase D, and a 5V rms, Phase E, output voltages. Refer to Figure 3-2 for the terminal identification for TB2.

J6 pins 5 and 6 are the External Sense input for the Phase D output. For the specified load regulation at the load, the External Sense input should be connected across the Phase D load.

3.4.7 CLOCK

J1 is supplied on the master power source when the LK option is ordered. This signal is used by California Instruments power controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option.

3.4.8 LOCK

J2 is supplied on the master power source when the LK option is ordered. This signal is used by California Instruments power controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option.

3.4.9 DFI (Discrete Fault Interrupt)

J3 is supplied when the MT option is ordered. This BNC connector is wired to a relay in the power controller. The normally closed relay contacts are held open by the power controller under normal running conditions. The contacts are allowed to close after a fault or if power is lost to the power source. The connector is installed as an option.

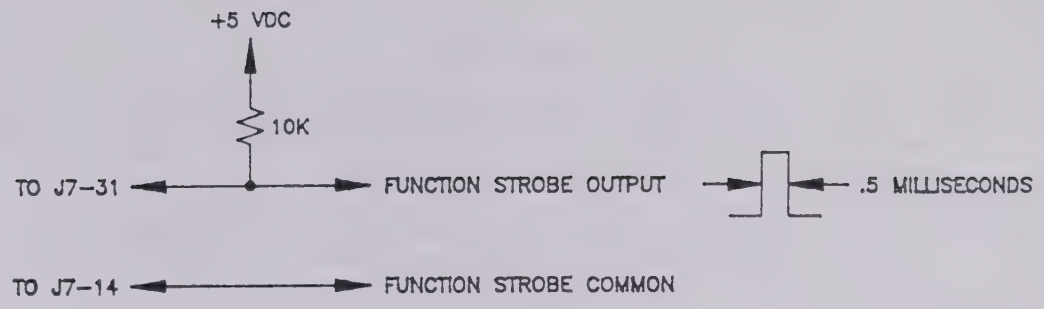


Figure 3-3

FUNCTION STROBE CONNECTIONS

3.5 FRONT PANEL PROGRAMMING

3.5.1 KEYPAD

The front panel keypad is enabled whenever the REMOTE light is not lit. The AC Power System may be manually programmed by using the keypad and observing the front panel LCD display.

Figure 3-4 shows the front panel keypad. Table 3-4 lists the key and a brief description. While viewing any Output Parameter screen (Ref. Table 3-5), the screens may be viewed in increasing order by depressing the MON key and in decreasing order by depressing the PRG key. While viewing the Measurement Screens, the MON and PRG keys work in a similar fashion. For example, if the AMP parameter screen is displayed, the FRQ screen may be displayed by pressing the MON key one time. The display will be switched back to the AMP screen by pressing the PRG key.

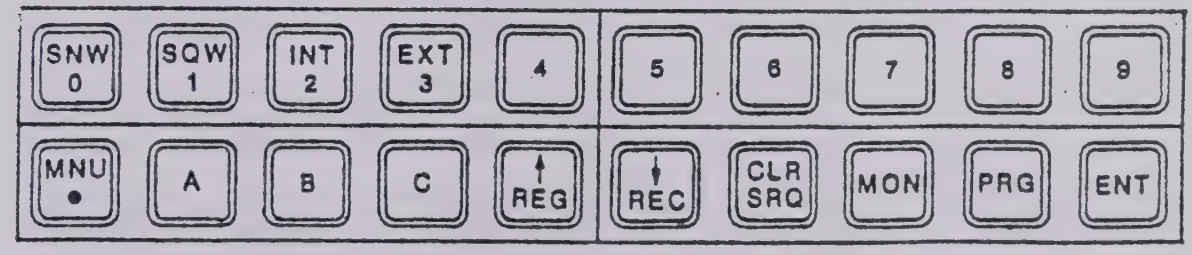


FIGURE 3-4

KEYPAD

KEY	DESCRIPTION
SNW/0	Inputs the value "0" for all output parameters or to select screen "0" when followed by the ENT key. Also used to select the sine wave waveform.
SQW/1	Inputs the value "1" for all output parameters or to select screen "1" when followed by the ENT key. Also used to select the square wave waveform.
INT/2	Inputs the value "2" for all output parameters or to select screen "2" when followed by the ENT key. Also used to select the Internal Synchronize or Internal Clock modes of operation.
EXT/3	Inputs the value "3" for all output parameters or to select screen "3" when followed by the ENT key. Also used to select the External Synchronize or External Clock modes of operation.
4 through 9	Inputs the indicated numeric value for all output parameters or to select the corresponding screen when followed by the ENT key.
MNU/.	Selects the Menu screens that show all display screens and the corresponding numeric value. The decimal point function of this key is enabled after any numeric key is depressed.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
C	Used to direct any parameter change to phase C. Also used to update any quantity in the display identified as C=.
↑/REG	Used to increment the value in any output parameter screen or calibration screen. Also used to load the program register into any register identified by the preceding numeric value.
↓/REC	Used to decrement the value in any output parameter screen or calibration screen. Also used to recall the program register identified by the preceding numeric value.

TABLE 3-4

KEYPAD KEY DESCRIPTION

KEY	DESCRIPTION
CLR/SRQ	Used to clear the numerical inputs for the display screen.
MON	Used to display programmed output parameter values. Used repeatedly, it will cause the display screens of increasing numeric numbers to be displayed.
PRG	Used to program setup values in the Program Register. Used repeatedly, it will cause the display screens of decreasing numeric numbers to be displayed.
ENT	Used to transfer the contents of the program register to the actual output parameters.

TABLE 3-4 (continued)

KEYPAD KEY DESCRIPTION

3.5.2 DISPLAY SCREENS

A display of data on the front panel LCD display is called a screen. There are five types of screens: menu, output parameter, measurement, calibration and configuration screens.

Menu screens display the screen abbreviation with its equivalent number. The numeric value for each item in a menu screen is the code that may be used to select the screen. Tables 3-5 through 3-8 show the numeric values for all screens. Without the aid of the tables the MNU key may be used. The menu screens will display only the programmable features that are enabled and their associated screen number.

Table 3-5 shows all of the available Output Parameter screens. While viewing any of the screens, the associated output parameter may be changed from the keyboard.

Table 3-6 shows all of the Measurement screens. When accessing some Measurement screens up to three seconds may be required to display the screen.

Table 3-7 shows all of the screens for calibrating the output and measurement functions. A special code is required to access these screens. Refer to Section 4, Calibration.

Table 3-8 shows all of the Configuration screens. The only value that is user programmable is the IEEE-488 (GPIB) Listen Address.

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for changing the output:				
1	SNC		INT, EXT	Selects phase A to be synchronized to an external input.
*2	CLK		INT, EXT	Selects the external clock mode of operation.
*3	WVF	A, B, C	SNW, SQW	Sets the output waveform.
4	RNG		Range limit	Selects the output voltage range. Range limit values of 135 and 270 are standard.
5	AMP	A, B, C	0-RNG limit	Sets the output voltage amplitude.
6	FRQ		45-5000	Sets the output frequency.
7	PHZ	A, B, C,	0-±999.9	Sets the output phase angle.
8	CRL	A, B, C	0 to Max Current	Sets the output current limit.
9	RMP A	DLY	0.001-9999	Sets the Delay between ramp steps in seconds. Four decade resolution from 0.001 to 9999 seconds.
		STP		Sets the step size of ramp parameter.
		VAL		Sets the final value of the parameter ramped.
	RMP B	STP		Same as RMPA
		VAL		Same as RMPA
28	DRP	A,B,C	0 to 5	Drop periods of sine wave
*30	MOD		PHS1 or PHS3	Selects output to be 1 phase or 3 phase

*Optional screen.
NOTE: RMPA and RMPB screens are not accessible until AMP, FRQ, CRL or PHZ are programmed (PRG) but not yet entered (ENT).

TABLE 3-5
OUTPUT PARAMETER SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for measured values.				
11	ELT	H, M, S	Hrs,Min,Sec	Reports the total accumulated run time up to 9,999 hours.
21	VLT	A, B, C	0-400.0	Measures the TRMS output voltage.
22	CUR	A, B, C	0.0-200.0 or 0.00-20.00	Measures the TRMS output current in Amps. Range depends on maximum current per phase.
23	PWR	A, B, C	0.00-27.00KW or 0-2000 watts	Measures the True output power. Range depends on output VA per phase.
24	PWF	A, B, C	0-1.000	Measures the power factor of the load.
25	APW	A, B, C	0.00-27.00KVA or 0-2000 VA	Measures the apparent output power. Range depends on output VA per phase.
26	FQM		40-5000	Measures the output frequency in hertz.
27	PZM	A, B, C	0-359.9	Measures the phase angle of the output voltage relative to phase A and phase A relative to an external input.

TABLE 3-6

MEASUREMENT SCREENS

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
13	CAL VLT	A, B, C	Actual output voltage	Calibrates the measured voltage to be the same as argument
14	CAL CUR	A, B, C	Actual output current (amps)	Calibrates the measured current to be same as argument.
15	CAL PWR	A, B, C	Actual output power	Calibrates the measured power to be same as argument. The argument is in KW for power systems of more than 2000 VA per phase.
20	POF	A, B, C	0-±359.9	Calibrates the programmed output phase angle.

TABLE 3-7

CALIBRATION SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
16	CFG	A(LSN)	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		B(CFG)	*28	Defines the features enabled for Power Source compatibility.
		C(PHZ)	*120	Defines the phase C initial value for power system configuration.
17	ALM	A(RNG)	0	Code that defines the default voltage range.
		B(LLM)	*135	Defines the upper limit of the lower voltage range.
		C(HLM)	*270	Defines the upper limit of the higher voltage range.
18	FLM	A(FRQ)	60	Defines the default frequency.
		B(LLM)	*45	Defines the low frequency limit.
		C(HLM)	*5000	Defines the high frequency limit.
19	CLM	A(RNG)	Max Current	Defines the maximum current limit value.
		B(PRS)	*0	Defines the decimal point location for measured power.
		C(CRS)	*2	Defines the decimal point location for measured current.
29	INI	A(AMP)	0-5	Defines default voltage.
		C(CRL)	0 - Max Current	Defines the default Current Limit.

*NOT USER PROGRAMMABLE. THE VALUES SHOWN ARE FOR A STANDARD 3-PHASE SYSTEM.

TABLE 3-8

CONFIGURATION SCREENS

3.5.3 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP=5)

NOTE

The external sense lines must be connected to J6 on the rear panel of the AC Power System. If they are not properly connected an AMP FAULT message will result when the output relay is closed. Refer to Figure 2-3.

The output voltage Amplitude may be programmed independently or simultaneously for each phase.

Select the Amplitude (AMP) screen by entering keystrokes:

5 ENT

The display now shows the AMP parameter screen:

```
AMP MON A = 0.0
B = 0.0 C = 0.0
```

NOTE: The B and C values are optional and they are only displayed with either a two or three-phase configuration.

Program all outputs to 115.5 volts with the keystrokes:

115.5 PRG ENT

Program phase A to 130.0, phase B to 110.0 and phase C to 90.0 volts simultaneously.

130 A PRG 110 B PRG 90 C PRG ENT

Slowly increase the output amplitude of phase B only:

B PRG ↑ (Hold until desired value is obtained.)

The output frequency can be programmed between 17 and 45 Hz. For operation between these frequencies, the output voltage Amplitude (AMP) is limited to values less than that described by the following formula:

AMP = Voltage Range * (FRQ)/45

3.5.4 TO PROGRAM FREQUENCY (FRQ=6)

Select the Frequency (FRQ) screen by entering the keystrokes:

6 ENT

Program the output to 60.23 hertz:

60.23 PRG ENT

To incrementally increase the output frequency to a desired value:

↑ (Hold until desired frequency is reached.)

The output frequency may be programmed down to 17 Hz if the programmed voltage Amplitude (AMP) is less than the full scale voltage range. The low frequency limit can be determined from the following formula:

FRQ = 45 * (AMP)/Voltage Range

3.5.5 TO PROGRAM OUTPUT PHASE ANGLE (PHZ=7)

Select the Phase (PHZ) screen by entering:

7 ENT

Program phase C to .5 degree relative the phase A:

0.5 C PRG ENT

To enable the External Sync input and to program phase A to 90.0 degrees relative to the External Sync input, perform the following sequence:

1. Select the SNC screen:

   1 ENT

2. Program EXT:

   EXT PRG

At this point the phase screen must be accessed by repeatedly depressing either the MON or PRG keys. After the Phase (PHZ) screen is displayed, enter the following key sequence to simultaneously enable the External Sync and program phase A to 90 degrees:

9 0 A PRG ENT

The up (↑) and down (↓) keys may be used to increment or decrement any or all output phases.

NOTE

The PHZ A value is maintained in nonvolatile memory. The last programmed value is retained at power-up.

3.5.6 TO PROGRAM CURRENT LIMIT (CRL=8)

The Current Limit can be programmed independently or simultaneously for each phase of the AC Power system.

1. Select the Current Limit screen by entering:

   8 ENT

2. Program all phases to 5 amps:

   5 PRG ENT

3.5.7 TO PROGRAM VOLTAGE RANGE (RNG=4)

The RNG screen has two purposes; to select a range defined by the range pair selected in the Amplitude Limit (ALM) screen and to select an upper voltage limit less than that specified by the ALM screen, LLM or HLM values. If the range pair 135/270 has been selected in the ALM screen with LLM=135 and HLM=270, the 135 range of the power source will be programmed by the RNG screen for any value of 135 or less. The value programmed will then be the maximum value allowed to be programmed in the Amplitude (AMP) screen.

To select the 270 range and set a program amplitude limit of 250 volts, perform the key sequence below:

4 ENT 250 PRG ENT

3.5.8 TO PROGRAM RAMP OR STEP FUNCTIONS (RMP=9)

The Ramp (RMP) function allows any programmable parameter (AMP, FRQ, PHZ, CAL or CRL) to be Stepped (STP) with a Delay (DLY) for each step to a final value (VAL). There are three types of programs that may be specified by the RMP screen; a ramp and two types of step programs.

The step function will program the output parameter value specified by a previous screen for the time specified for the DLY value in seconds. The parameter will then return to a final value specified by the VAL value.

The ramp function will step the output parameter value specified by a previous screen with the STP value, the DLY time per step and the final VAL setup in the RMP screen. The ramp will increment if the VAL value is larger than the parameter value. It will decrement if it is less than the parameter value.

NOTE

The DLY, STP or VAL parameters must be specified (A, B or C key depressed) before the number value for the parameter is entered.

When ramping frequency, an error message will result with an attempt to step the frequency with greater resolution than that possible by the initial or final values.

The step program may also be used to generate a dropout to zero volts on phase A at any point on the waveform. This type of program is selected by setting the AMP value to zero before setting the DLY and VAL parameters. The point on the waveform at which the dropout occurs is specified by setting the A value in the (PHZ) screen.
The following key sequence will program 130V for 2.5 seconds and then return to a final value of 115V.

1. Select the AMP screen and enable 130 volts to be programmed:

   5 ENT 130 PRG (*)

2. Select the RMP screen, program a DLY of 2.5, a final VAL of 115 volts and run the program:

   9 ENT A 2.5 PRG C 115 PRG ENT

The next example will illustrate a ramp program. The following sequence will ramp the frequency from 60 hertz to 400 hertz in .1 hertz steps with a delay (DLY) for each step of .003 seconds. The total time for this ramp will be = [(VAL- FRQ)/STP]DLY or 10.2 seconds.

1. Select the FRQ screen and set the starting frequency of 60 Hz:

   6 ENT 60 PRG

2. Select the RMP screen, set a DLY of .003, set the STP of .1, set the final VAL of 400 and run the program:

   9 ENT A 0.003 PRG B 0.1 PRG C 400 PRG ENT

(*)If the ENT key is depressed at this point, the AMP would be programmed to and remain at 130 volts.

The following program will illustrate a dropout to zero volts. The program will drop the output to zero volt at 90 degrees for .002 seconds and return to 115 volts. This example will cause the Clock to stop for 0.002 seconds. For this example the output waveform will start at the same point that it stopped.

1. Select the AMP screen and program output to 115 volts:

   5 ENT 115 PRG ENT

2. Select the PHZ screen and program A to 90:

   7 ENT 90 A PRG

3. Select the AMP screen and program the dropout voltage to zero volt:

   5 ENT 0 PRG

4. Select the RMP screen. Set a delay of .002 seconds and a return value of 115 volts:

   9 ENT A 0.002 PRG C 115 PRG

5. Execute the program by depressing the ENT key.

Two output parameters may be ramped simultaneously. The parameter programmed just prior to entering the RMP A screen will be the independent parameter and will be identified in that screen. The parameter loaded prior to the independent parameter will be the dependent parameter.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen (dependent parameter) and program the start to 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen (independent parameter) and program the start frequency of 360 Hz:

   6 ENT 360 PRG

3. Select the RMPA screen and program the independent ramp parameters of STP = .2, and DLY = .2 and VAL = 440:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMPB screen and program the dependent (AMP) ramp parameters of STP = .5:

   10 ENT B 0.5 PRG

5. Start the program by pressing the ENT key.

The final value of the dependent parameter, AMP, will be determined by the number of steps of the independent parameter and the STP value, .5V specified in RMP B.

FINAL VALUE = INITIAL VALUE + (RMP B STP) (NO. STEPS)
NO. STEPS = (DEP. PAR.) (FINAL VALUE - INITIAL VALUE)/STEP SIZE

In this example:

NO. STEPS = (440 - 360)/.2 = 400

FINAL AMP VALUE = 10 + .5 X 400 = 210 Volts

If the final value exceeds the RNG value, an error message will be generated.

NOTE

Any ramp may be terminated at any time by depressing the ENT key.

3.5.9 TO PROGRAM THE OUTPUT WAVEFORM (WVF=3) (SQW Option)

The waveform selection is an option for the AC Power system. If the screen cannot be selected the option is not enabled.

The WVF screen displays the type of waveform selected, sine wave (SNW) or square wave (SQW), for each of the three outputs. To program a square wave, depress the SQW or any odd number key followed by any combination of the A, B or C key, the PRG key and ENT key. If no phase key is depressed, the new waveform will be programmed for all outputs.

To program phase A and C to square wave:

SQW A C PRG ENT

To select the sine wave waveform for any phase depress the SNW or any even number key followed by the key sequence described above.

3.5.10 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC=1)

The SNC screen displays whether the external or internal SNC mode of operation has been selected. While viewing this screen to select the external SNC mode, depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

While operating in the EXT SNC mode, the FRQ screen will display the frequency of the External Sync signal. The signal must be between 45 Hz and 550 Hz.

NOTE

When viewing the SNC, CLK or WVF screens, the MON or PRG keys must be used to sequence to another screen. The MNU key can also be used to return to the menu then followed by any screen selection.

To return to the internal SNC mode of operation, depress the INT key or any even numeric key followed by the PRG and ENT key while viewing the SNC screen.

Example: INT PRG ENT

If the External Sync signal is not between 45 Hz and 550 Hz, the message will be 'EXT SYNC ERROR'.

In the EXT SNC mode the A value on the PHZ screen represents the angle of the A output leading the External Sync input. If the zero degree point of the power source does not match the zero degree point of the External Sync input, the POF screen may be used for calibration. Select the POF screen and enter a value for calibration.

3.5.11 TO PROGRAM THE EXTERNAL CLOCK (CLK=2) (LK Option)

The clock selection is an option for the AC Power System. The CLK screen displays whether the AC Power System is operating in the external (EXT) or internal (INT) CLK mode of operation. While viewing this screen to select the EXT CLK mode, depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

NOTE

Before selecting the External clock mode, ensure that the AC Power System containing the oscillator has the proper clock and lock signals applied to the BNC connectors on the rear panel. Failure to have the proper clock and lock signals when the EXT CLK mode of operation is selected may result in an AMP FAULT error message. No output from the AC Power System will be available.

To return to the internal (INT) CLK mode of operation, depress the INT or any even numeric key followed by the PRG and ENT key while viewing the CLK screen.

Example: INT PRG ENT

3.5.12 TO PROGRAM REGISTERS AND RAMPS

The AC Power System has 16 registers that can be used to store setups. All of the data stored in the registers will be retained during power-down. Register operation may be chained to another register by adding the REC and register number to any setup sequence. The REC and REG keys are used for register operations. Any of the previous examples may be stored in a register by adding the extra step of entering the register number followed by depressing the PRG key. This extra step must be entered before the last ENT keystroke.

The following program will program 135 volts and 60 hertz on all outputs for 10 seconds before reducing the output to 115 volts and store the test in register 0.

1. Select the FRQ screen and program 60 hertz:

   6 ENT 60 PRG

2. Select the AMP screen and program 135 volts:

   5 ENT 135 PRG

3. Select the RMP screen and program DLY = 10 and VAL = 115

   9 ENT A 10 PRG C 115 PRG

4. Store the program in register 0:

   0 REG

To recall and perform the register operation, simply enter the register number followed by depressing the REC and ENT keys.

3.5.13 REGISTER LINKING

Any number of registers may be linked together by using the REC key prior to loading the register operation.

The following program will ramp the voltage from 115 volts and 60 hertz to 135 volts with .1 volts per 10 millisecond steps, remain at 135 volts for 10 seconds, return to 115 volts at the same rate but at 62 Hz. Store the program in Registers 1 and 2.

1. Select the FRQ screen and program 60 Hz:

   6 ENT 60 PRG

2. Select the AMP screen and program 115 volts:

   5 ENT 115 PRG

3. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 135:

```
9 ENT A 0.01 PRG B 0.1 PRG C 135 PRG
```

4. Link this program to Register 2:

```
2 REC
```

5. Store this program in Register 1:

```
1 REG ENT
```

The second portion of the program will be stored in Register 2.

6. Select the FRQ screen and program 62 Hz:

```
6 ENT 62 PRG
```

7. Select the AMP screen and program 135 volts:

```
5 ENT 135 PRG
```

8. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 115:

9. Store this program in Register 2:

```
2 REG ENT
```

To initiate the program:

```
1 REC ENT
```

3.5.14 TO PROGRAM SIMULTANEOUS RAMPS

Two outputs may be simultaneously ramped or stepped by enabling two parameter screens. The screen first selected will be the dependent parameter. The last parameter screen selected before entering the ramp (RMP) screen is the independent parameter. The independent parameter is used to specify the number of steps in a ramp. Since the dependent parameter has as many steps as the independent parameter, the step (STP) size must be calculated so the dependent parameter will not exceed its maximum value. The following example will specify frequency as the independent parameter and phase as the dependent parameter. Refer to paragraph 3.5.8 for more information.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen and specify the starting voltage of 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen and specify the starting frequency of 360 Hz.

   6 ENT 360 PRG

3. Select the RMP A screen and specify the ramp parameters of the independent parameter, FRQ, of DLY = .2 seconds, STP = .2 Hz and VAL = 440 Hz:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMP B screen and specify the ramp parameter of the dependent parameter, AMP, of STP = .5 volts:

   10 ENT B 0.5 PRG

5. At this point the program may be executed by depressing the ENT key or stored in a register.

3.5.15 ERROR MESSAGES

Table 3-9 shows all of the possible error messages displayed on the front panel display. The cause of the error message is also shown.

3.5.16 TO PROGRAM FREQUENCY, VOLTAGE, VOLTAGE RANGE AND CURRENT LIMIT DEFAULT VALUES

The default values are the values that appear at power-up and after the GPIB Device Clear command.

To set any of the default values perform the following steps:

1. Depress the MNU key several times until the first menu screen is displayed as illustrated below:

   ```
    SNC = 01        *CLK = 02
   *WVF = 03         RNG = 04
   ```

NOTE (*) May not be displayed. Depends on options.

2. Enter the key sequence: 9 5 9 ENT

ERROR MESSAGE	CAUSE
CRL FAULT	Indicate output current exceeds program current.
AMP (1) FAULT	Incorrect sense line connection. Overload on indicated output.
TEMP (1) FAULT	Amplifier overtemperature
CPU MEMORY FAULT	CPU failed self-test
DMA OVERFLOW	Remote message greater than 256 bytes.
EXT SYNC ERROR	No external sync input at System Interface connector. Signal is not between 45 and 2 or 5 KHz.
BUS LOCAL ERROR	Remote message sent while AC Power System is in local.
SYNTAX ERROR	Incorrect syntax received from IEEE-488 External Interface
AMP RANGE ERROR	Attempt to program AMP value greater than RNG value.
FRQ RANGE ERROR	Attempt to program FRQ less than 45 (2) or greater than 2 or 5 KHz.
PHZ RANGE ERROR	Attempt to program PHZ greater than ±999.9
CRL RANGE ERROR	Attempt to program CRL greater than 11.11 or 33.33.
RNG RANGE ERROR	Attempt to program RNG greater than 270.0 or other optional high voltage range.
RMPA RANGE ERROR	Attempt to program STP, DLY or VAL greater than the maximum.
DIV ERROR	Consult factory.
OVERFLOW ERROR	Consult factory.

(1) May be any combination of A, B or C.

(2) May be down to 17 Hz with reduced output voltage.

FRONT PANEL DISPLAY ERROR MESSAGES

TABLE 3-9

3. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

To program the default frequency, enter the key sequence:

1 8 ENT A

next enter the default frequency followed by depressing the PRG and ENT key.

To program the default voltage range, perform step 1 through 3. Next enter the key sequence:

1 7 ENT A

At this point, if 0 is entered, the default voltage range is the Low Range.

If an 8 is entered, the default voltage range will the High Range.

To make the High Range the default, continue the key sequence with:

8 PRG ENT

To program the default voltage, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT A

At this point the default voltage from 0 to 5 may be entered. If a value of less than 5 volts is entered, the output may fault when a voltage is programmed to a value that is less than 50% of full scale.

To make 5 volts the default voltage, continue the key sequence with:

5 PRG ENT

To program the default current limit, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT C

At this point, any value may be entered up to the maximum current available per phase.

To make 5 amps the default value, continue the key sequence with:

5 PRG ENT

3.5.17 TO PROGRAM 1 OR 3 PHASE MODE (MOD=30) (MOD Option)

The MOD selection is an option for the AC Power System. When the option is installed, the AC Power System may be programmed to either be a 1-phase or a 3-phase power system.

The MOD screen displays the output configuration of the power system, 1-phase (PHS1) or 3-phase (PHS3).

To program the power system to the 3-phase output mode, enter the following key sequences:

Select the MOD screen: 3 0 ENT

Program the 3-phase mode: 3 PRG ENT

The last mode programmed for the power system will be the default Mode at power-up.

3.5.18 TO PROGRAM THE DROP PERIODS (DRP=28)

Select the phase (PHZ) screen by entering the keystrokes:

7 ENT

The display will show the PHZ parameter screen

PHZ MON A = 0.0 B = 240.0 C = 120.0

To drop the output waveform starting at 90 degrees, enter the keystrokes 90 A PRG.

Select the Drop screen (DRP=28) by entering the keystrokes 2 8 ENT.

The display will show the DRP parameter screen.

DRP MON A = 0 B = 0 C = 0

To drop the output waveform for phase A for 3 cycles enter the keystrokes"

3 A PRG ENT

Verify that phase A drops at the 90 degrees point of the sine wave for 3 periods of the programmed frequency.

3.6 TO MEASURE THE OUTPUT

Seven measurement screens display the output voltage, current, power, apparent power, power factor, phase and frequency. The phase A, B and C output values are shown simultaneously for 3-phase systems.

While viewing any measurement screen, except ELT, any other measurement screen may be displayed by repeatedly depressing either the MON or PRG key. The screen may also be displayed by entering its equivalent screen number followed by depressing the ENT key. Refer to Table 3-6 for all measurement screen numbers.

3.6.1 TO MEASURE THE OUTPUT VOLTAGE (VLT=21)

The voltage screen displays the actual TRMS output voltage with 0.1 volt resolution. This voltage is the voltage at the External Sense connector of the AC Power System. To access the voltage screen, depress the keys:

21 ENT

3.6.2 TO MEASURE THE OUTPUT CURRENT (CUR=22)

The current screen displays the actual TRMS load current. The resolution is 0.01 amp for the 4500L-3P and 2750L-3P. The resolution is 0.1 amp per phase for all other P power systems.

3.6.3 TO MEASURE THE OUTPUT POWER (PWR=23)

The power screen displays the actual true power delivered to the load. The resolution is 1 watt for the 4500L-3P and 2750L-3P. The resolution is 0.01 KW per phase for all other P power systems.

3.6.4 TO MEASURE THE OUTPUT POWER FACTOR (PWF=24)

This screen displays the power factor from 0 to 1.000 with 0.001 resolution. The PWF screen will read unity for loads less than 10 digits of apparent power on the Apparent Power (APW) screen. When this screen is displayed after another screen, it takes approximately one second to update the screen.

3.6.5 TO MEASURE THE OUTPUT APPARENT POWER (APW=25)

This screen is accessed by its screen number, 25. It displays VOLT-AMPERES with a resolution of 1 VA for 4500L-3P and 2750L-3P. The resolution is 0.01 KVA per phase for all other P power systems.

3.6.6 TO MEASURE THE OUTPUT FREQUENCY (FQM=26)

This screen is accessed by its screen number, 26. It displays the measured output frequency with a resolution of 0.01 Hz, 0.1 Hz or 1 Hz up to 99.99 Hz, 999.9 or 5000 Hz, respectively.

3.6.7 TO MEASURE THE OUTPUT PHASE ANGLE (PZM=27)

This screen is accessed by its screen number, 27. It displays phase A relative to an external synchronizing input and phase B and C relative to phase A. The resolution is 0.1 degree.

3.6.8 ELAPSED TIME (ELT =11)

This screen displays the total run time accumulated on the AC Power System up to 99,999 hours.

H = Hours M = Minutes S = Seconds

3.7 REMOTE PROGRAMMING WITH ABBREVIATED PLAIN ENGLISH (APE)

Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alphanumeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-10. These abbreviations must not be confused with the device dependent abbreviations used to describe the AC Power System operating parameters (ex. FRQ=Frequency, etc.).

3.7.1 UNIT ADDRESS

This is the A value (LSN) set in the CFG screen. The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-11 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1 but may be changed by selecting the CFG Configuration screen and setting a new value.

To select the CFG screen repeatedly depress the MNU key until menu screen #1 is displayed as illustrated below:

```
SNC = 01        CLK = 02
WVF = 03        RNG = 04
```

Enter the key sequence: 959 ENT

Repeatedly depress the MNU key until the menu screen #5 is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

Enter the key sequence: 16 ENT

The CFG screen will now be displayed. Depress the A key to display the present Unit Address. It may be changed to any value from 0 to 30 and will be stored in non-volatile memory. The new unit address will not be updated until power is shut off and reapplied to the power system.

The following key sequence will change the unit address to 16:

16 PRG ENT

TABLE 3-10.
COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states..
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End or Identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
LLO	Local Lockout. A GPIB message, when asserted, will inhibit the instrument from going to local if the CLR/LOC key is pressed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to local when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to it Power-on state.

TABLE 3-11.

UNIT ADDRESS GROUP

LISTEN ADDRESS	HEX	BINARY						DECIMAL	ASCII
			A5	A4	A3	A2	A1		
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	'
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

3.7.2 MESSAGE FORMAT

The message sent to the AC Power System must have the following format for each parameter:

HHHDXXX----------E±NND

where

H = Three letter mnemonic for each message header.

D = Optional header extension (A, B or C) to specify output (ref. Table 3-5 through 3-8)

X = Alpha, numeric or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter, (CR) (LF) or (LF)

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

3.7.3 NUMERIC DATA FIELD

Parameter values may be sent as an unsigned value with a decimal point or a decimal point with an exponent. The phase value may be sent as a signed value.

The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts.

```
AMP115
AMP115.0
```

There may be any number of digits following the decimal point, not to exceed the 256 byte DAM buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is 0.1 volts. The LSD for frequency is either 0.01, 0.1 or 1 Hz for up to 99.99, 999.9 or 5000 Hz respectively.

Any parameter's numeric value may be of a mixed form with a decimal point and exponent. The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 15 volts:

```
AMP1.15E2
AMP1.15E+2
AMP1.15E+02
AMP1150E-1
```

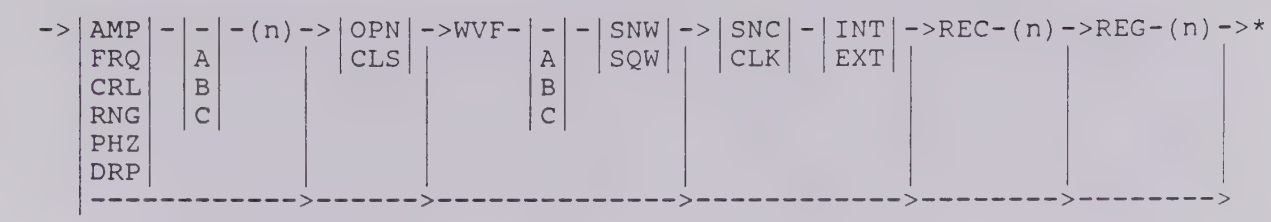
A positive exponent value is represented by either an ASCII "+" or an unsigned value.

3.7.4 PROGRAM HEADERS

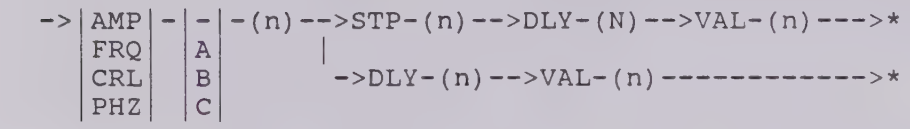
A Program Header is a mnemonic of a series of three ASCII characters used to select a function or identify the data it precedes. The header is an abbreviation of the program function it identifies. The header may be followed by a header extension to separately program each output (phase A, B or C) to different values. If an extension is not added to the header all outputs will be programmed to the header's argument. See Table 3-12 for the definition of the Program Headers and their related arguments.

Any header that is sent without an argument will cause the front display to show the corresponding screen. Refer to Figure 3-5 for a summary of all possible command sequences.

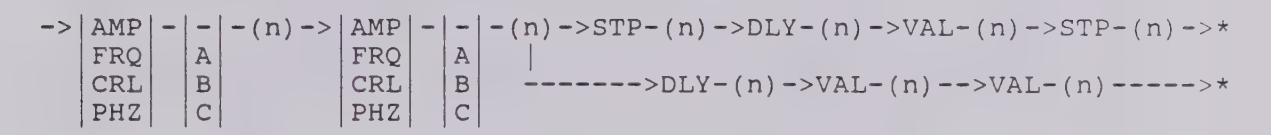
TO PROGRAM OUTPUT PARAMETERS:



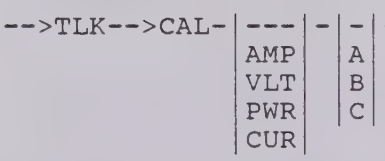
TO RAMP OR STEP ONE OUTPUT PARAMETER:



TO RAMP OR STEP TWO OUTPUT PARAMETERS:



TO REQUEST TALKING OF CALIBRATION COEFFICIENTS:



TO PROGRAM THE OUTPUT MODE

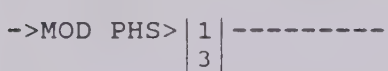
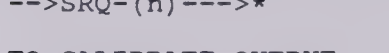


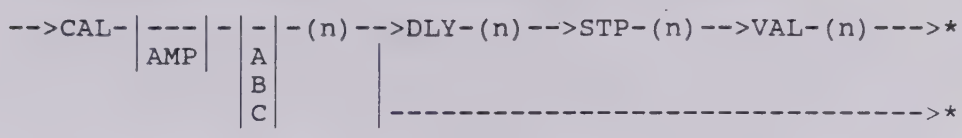
FIGURE 3-5

REMOTE COMMAND SEQUENCES

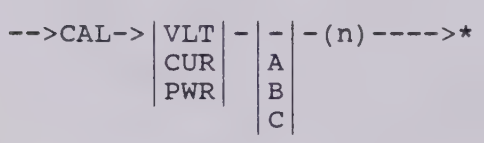
TO SPECIFY THE SERVICE REQUEST INTERRUPT:



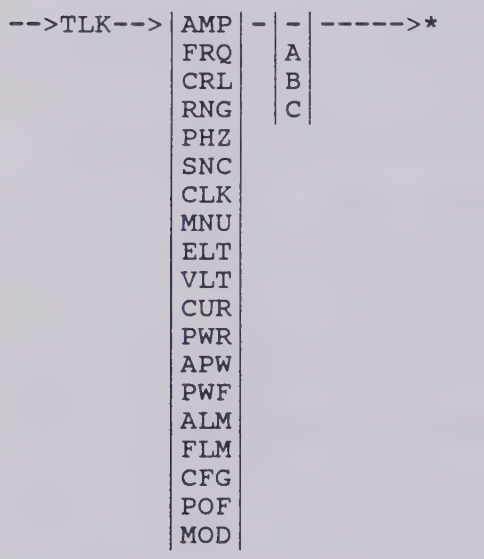
TO CALIBRATE OUTPUT:



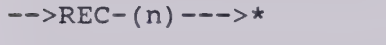
TO CALIBRATE MEASUREMENT:



TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:



TO RECALL A REGISTER:



* Represents either an IEEE-488 END or EOS message. The EOS message may be either an ASCII Carriage Return(CR), Line Feed(LF) or just LF.

n Represents a numeric value.

FIGURE 3-5 (continued)

REMOTE COMMAND SEQUENCES

TABLE 3-12
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
AMP	A, B, C	# or numeric from 0.0 to RNG value.	Amplitude in volts.
CAL	A, B, C	0 to 255	Calibrate the output voltage
CAL VLT	A, B, C	Actual voltage	Calibrated measured voltage at external sense point.
CAL CUR	A, B, C	Actual current	Calibrate measured current.
CAL PWR	A, B, C	Actual power	Calibrate measured power.
CLK		INT, EXT	Clock source
CRL	A, B, C	0 to maximum current per phase	Current limit in amps
DLY		0.000 to 9999	Delay in seconds used as a seconds ramp parameter
DRP	A, B, C	1 through 5	Number of Drop cycles
FRQ		45.00 to 5000	Frequency in hertz.
PHZ	A, B, C	0 to 999.0	Phase angle in degrees.
PRG		0 through 15	Load register with preceding data.
REC		0 through 15	Recall register or specify link register if it is preceded by program argument followed by PRG and register number.
REG		0 through 15	Register load
RNG	A, B, C	0.0 to 270 or other optional range value	Amplitude range and limit value in volts
SNC		INT,EXT	Synchronize

TABLE 3-12 (CONT.)

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program and measurements.
STP		From parameter minimum to maximum value	Define step size in ramp.
TLK		Any header	Set up to talk argument value or measured value when addressed to talk.
TRG			Execute (Trigger) set-up parameters on GPIB "GET" message.
VAL		From parameter minimum to maximum value	Final ramp or step value in volts, hertz, amps, degrees, sine wave or square wave.
WVF	A, B, C	SNW,SQW	Waveform
OPN			Open output relays
CLS			Close output relays
VLT	A, B, C		Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
CUR	A, B, C		Used with TLK to request measurement of the output load current.
MOD	PHS	1 or 3	Program the output phase configuration

TABLE 3-12 (CONT.)

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
PWR	A, B, C		Used with TLK to request measurement of the True output power.
APW	A, B, C		Used with TLK to request measurement of the Apparent output power.
PWF	A, B, C		Used with TLK to request measurement of the output power factor.
PZM	A, B, C		Used with TLK to request measurement of the output phase angle.
FQM			Used with TLK to request measurement of the output frequency.

NOTE: If Extension does not follow the header, the argument will be applied to all phases.

3.7.5 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP)

The AMP header with the optional A, B or C extension is used to identify the amplitude command. The argument is a numeric data field from 0.0 to the limit set by the RNG value. An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB.

The following ASCII strings will program the voltage given in the left column:

A,B,C 0.0 volts	AMP0	or	AMPA0AMPB0AMPC0		
A,B,C 10.5 volts	AMP10.5	or	AMP1.05E1	or	AMP105E-1
A,B,C 100 volts	AMP100	or	AMP100.0	or	AMP1E2
A,B = 110.5, C = 115	AMPA110.5AMPB110.5AMPC115 or AMP110.5AMPC115				

3.7.6 TO PROGRAM FREQUENCY (FRQ)

The FRQ header is used to identify the following numeric data as frequency.

The following string will program the frequency to 60.56 Hz.

```
FRQ 60.56
```

3.7.7 TO PROGRAM PHASE ANGLE (PHZ)

The PHZ header with the optional A, B or C extension is used to identify the following numeric data as phase. The PHZ header sent with no extension will program the B and C outputs in phase with phase A. The phase of the A output will lead the EXT SNC signal by the value programmed.

The following example will program the phase A output to 90 degrees relative to an external sync signal when operating in the EXT SNC mode:

```
PHZA 90
```

The following example will program phase B to 240.5 degrees and phase C to 119.3 degrees leading phase A.

```
PHZB 240.5 PHZ C 119.3
```

The PHZA value can be used to control the point of the phase A waveform where the change will occur. The following example will drop the phase A waveform at 90 degrees for 0.017 seconds before going to 115 volts.

```
PHZA 90 AMP0 DLY .017 VAL 115
```

The following example will increase the phase A output voltage to 135 volts for 0.017 seconds starting at the 90 degree point of the waveform. The voltage will return to 115 volts after the transient.

```
PHZA 90 AMPA 135 DLY .017 VAL 115
```

3.7.8 TO PROGRAM CURRENT LIMIT (CRL)

The CRL header with the optional A, B or C extension is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to the maximum rated current of the power system.

The following string will program a current limit of 10.5 amps for all three phases:

```
CRL 10.5
```

3.7.9 TO PROGRAM CALIBRATION (CAL)

The CAL header when used alone or followed by the header AMP, in addition to an A, B or C extension, is used to calibrate the programmed output voltage. The argument is a relative starting coefficient from 0 to 255 or the ASCII # symbol. The CAL ramp is terminated with the GPIB message Group Execute Trigger (GET). The CAL header can be used with a Delay (DLY) command to allow the external calibration AC DVM time to settle. Refer to Section 4 for additional information.

A CAL coefficient can be programmed without a ramp by using only the argument with the CAL header.

To program the CAL A coefficient to 55, use the following string:

```
CALA55
```

To calibrate phase A at 135 volts, start the CAL routing with a GPIB GET message with the CAL coefficient starting at 20 and with each step lasting 2 seconds, use the following string:

```
AMP135.0 CALA20 DLY2 STP1 VAL255 TRG
```

In this example the output will program to 135.0 and start to change the output by stepping the CAL value after a "GET" message. the ramp will terminate after a second "GET" message.

The following example will calibrate the phase A output by starting the ramp with the existing CAL coefficient and reducing the output with steps lasting one second:

```
AMP135.0 CALA# DLY1 STP1 VAL0
```

Again the ramp must be terminated with the bus "GET" message when the external AC calibration DVM indicates the correct voltage.

The CAL header is used with the headers VLT, CUR and PWR to calibrate the respective measurement function. An A, B or C extension follows the headers to designate a specific measurement channel. If the extension is omitted, the calibration coefficients for all measurement channels will be the same and will depend on only the value for phase A. The arguments is a numeric value that represents the expected measured value. It should be equal to an external precision TRMS voltmeter, ammeter or power meter.

The following ASCII string will cause the current measurement for phase A to measure the value indicated by a TRMS ammeter standard, 10.12 amps:

```
CAL CUR A 10.12
```

3.7.10 TO PROGRAM RAMP OR STEP OPERATIONS

The DLY header is used with a parameter that has a numeric argument (ex. AMP, FRQ, PHZ, CRL, CAL) in a single step program. The numeric argument is in seconds with four decade resolution from 0.001 to 9999 seconds.

The STP header with VAL may be used with DLY to completely specify a ramp program.

The following string will first step the voltage to 125 volts for 2.55 seconds and return to 115 volts.

```
AMP 125 DLY 2.55 VAL 115
```

The following string will ramp the voltage from 10 volts to 115 volts with 1.5 volt/.5 sec. steps:

```
AMP 10 DLY .5 STP 1.5 VAL 115
```

When an AMP header with an argument of 0 is used, the waveform will stop and drop to zero volts at the point specified by the PHZ A value.

The following ASCII string will stop the waveform at 0 degrees for .01 seconds and return to 115 volts:

```
PHZ A 0 AMP 0 DLY .01 VAL 115
```

The STP header is used to identify a numeric value as the increment or decrement value for a FRQ, CRL, AMP, PHZ or CAL ramp.

The following example will ramp all outputs from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

```
AMP130 DLY.5 STP1.5 VAL10
```

The header VAL is used to identify the following numeric argument as the final Value of a ramp or step. If the VAL argument is larger than the initial value for the parameter to be ramped, the ramp will increment with step size defined by STP and DLY. With the VAL argument less than the initial value, the ramp will decrement from the initial parameter.

A ramp or step operation can be started at anytime by the GPIB message Group Execute Trigger (GET). The operation will wait for the Group Execute Trigger when the TRG header is added to the string.

The following example will decrement the output amplitude of phase A only from 120 in .1 volt/.2 sec steps to 100 volts after a Device Trigger.

```
AMP A 120 DLY.2 STP.1 VAL100 TRG
```

The following example will simultaneously ramp the Frequency from 400 to 500 Hz at a rate of 0.1 Hz per second and the Amplitude from 5 volts in increments of .5 volts per step:

```
RNG270 AMP5 FRQ400 STP.1 DLY1 VAL500 STP.5
```

A GPIB Service Request will be generated at the end of a ramp if SRQ2 is included in the setup string.

A ramp operation can be stopped at anytime by the GPIB Group Execute Trigger.

3.7.11 TO PROGRAM A REGISTER (REG)

The REG header is used to load the register specified by the following numeric data with the preceding data. The numeric value is from 0 to 15. The PRG header is identical to the REG header and is included to standardize other AC power controllers.

The following example will load a ramp program that will step the voltage from 10 to 115 volts with 1 volt/.5 sec steps at 400 Hz into register 0.

```
FRQ400 AMP10 DLY.5 STP1 VAL115 REG0
```

3.7.12 TO RECALL A REGISTER (REC)

The REC header is used to recall previously loaded data from a register identified by the following register number (0 to 15).

The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3.7.11.

```
REC0
```

The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" message.

```
REC0 TRG
```

The following is an example of register linking. The voltage and frequency is maintained at 115 volts and 60 Hz for 5 seconds and then the program contained in register 0 is recalled and executed. The program is stored in register 1.

```
FRQ60 AMP115 DLY5 VAL115 REC0 REG1
```

The program is initiated by the following ASCII string:

```
REC1
```

3.7.13 TO PROGRAM VOLTAGE RANGE (RNG)

The RNG header is used to select a range. The numeric value following the RNG header will also define the upper limit for the AMP value. The RNG value will select the higher range if the value is greater than the lower range value defined by the ALM screen which is 135 for the standard voltage range. If the range and voltage amplitude are to be programmed by the same data string the RNG header and argument must precede the AMP header or a syntax error will be generated.

The following example will select the 270 range from the 135/270 range pair with an upper amplitude limit of 210 volts.

```
RNG210
```

3.7.14 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC)

The SNC header is used with the EXT argument to synchronize the phase A output to an external sync input. The phase A output will be phase referenced to the sync input with the displacement equal to the PHZ A value.

The following ASCII string will program the phase A output to 0 degree relative to the external sync input and select the external sync mode.

```
PHZA0 SNC EXT
```

Sending the ASCII string SNC INT will disable the sync input.

3.7.15 TO PROGRAM EXTERNAL CLOCK (CLK) (optional)

The CLK header has an argument of either EXT or INT. The CLK header with the EXT argument will make one AC Power System a slave to another system. The slave will operate at the same frequency as the master. Phase A of the slave will be related to phase A of the master by the PHZ A value of the slave.

NOTE

The clock option is only available if the associated power systems have the LK option.

The following ASCII string will enable the CLOCK and LOCK inputs to the associated slave AC Power System:

CLK EXT

NOTE

If there is no signal at the CLOCK input at the rear panel of the associated power system, the output will go to zero volts.

The ASCII string CLK INT will return the slave AC Power System to its programmed frequency.

3.7.16 TO TRIGGER AN OPERATION (TRG)

The TRG header has no argument. When the TRG mnemonic is included in a setup string, it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller. The TRG header may also be used to trigger register operations by including the TRG header with the string used to recall a register. The following example will delay execution of the program in register 1 until an IEEE-488 Device Trigger is received:

REC1 TRG

The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The setup values will then be programmed in the remote mode when the Device Trigger is received.

3.7.17 TO PROGRAM THE OUTPUT WAVEFORM (WVF) (Optional)

The header WVF with the optional A, B or C extension is used to identify the following argument as the Sine Wave (SNW) or Square Wave (SQW) function of the Waveform.

The following example will program all outputs to the square wave function.

```
WVF SQW
```

The following example will program only output B to the square wave function:

```
WVFB SQW
```

3.7.18 TO OPEN (OPN) AND CLOSE (CLS) THE OUTPUT RELAY

The OPN and CLS headers open and close the output relays in the power source. There is no argument associated with these headers. When the OPN or CLS headers is received the output voltage will be programmed to zero volts for 50 milliseconds before the output relays open or close.

3.7.19 TO PROGRAM DROP CYCLE (DRP)

The DRP header is used to identify the Drop Command. The argument is a numeric data field from 1 to 5. The following string will drop the output voltage for phase B for five complete cycles and start at 0 degree of the wave form. Note that all drop angles are relative to Phase A.

```
PHZ A 120 DRP B
```

3.7.20 TO PROGRAM THE DEFAULT FREQUENCY (FLM A)

The default frequency is the output frequency after power-up or after an IEEE-488 Device Clear.

The following example will program the default frequency to 400 Hz.

```
FLM A 400
```

3.2.21 TO PROGRAM THE DEFAULT OUTPUT VOLTAGE (INI A)

The default voltage is the output voltage after power-up, IEEE-488 Device Clear or an Amplitude fault.

The following example will program the default voltage to 5 volts.

```
INI A 5
```

NOTE

If the default voltage is programmed to a value less than 5 volts, the settling time will increase. In addition, there may be an amplitude fault when the voltage is programmed from the default voltage to a value less than 50% of full scale.

3.7.22 TO PROGRAM THE DEFAULT CURRENT LIMIT (INI C)

The default current limit is the value after power-up or IEEE-488 Device Clear.

The following example will program the default current limit to 10 amps.

```
INI C 10
```

3.7.23 TO PROGRAM THE DEFAULT VOLTAGE RANGE (ALM A)

The default voltage range is the voltage range after power-up or IEEE-488 Device Clear. A value of 0 designates the low-range. A value of 8 designates the high range.

The following example will program the default voltage range to the high range.

```
ALM A 8
```

3.7.24 TO PROGRAM 1 OR 3 PHASE MODE (MOD)

The MOD header with the required PHS extension is used to identify the mode command. The argument is either a 1 or a 3 to specify the 1-phase or 3-phase mode respectively. A mode change by the AC Power System will cause the output voltage to go to the default values.

The following string will set the AC Power Systems to the 3-phase mode:

```
MOD PHS 3
```

3.7.25 TO TALK (TLK) MEASURED AND PROGRAMMED DATA

The TLK header will setup the AC Power System to talk data. The TLK header will setup the AC Power System to report a programmed output parameter if the program header is the argument for the TLK header.

To setup the AC Power System to report a measured value, attach a measurement header as the TLK argument. The measurement headers are VLT, CUR, PWR, APW and PWF with an A, B or C extension and FQM with no extension.

The following string will setup the AC Power System to measure the phase A power output when it is talk addressed:

```
TLK PWR A
```

All arguments for the TLK header are shown in Table 3-13. Table 3-14 shows an example response for all TLK arguments with no A, B or C extension. For 1-phase systems, all responses will only include the phase A value. For 3-phase systems, if the TLK argument includes the A, B or C extension, the response message will be only for the indicated phase.

A GPIB Service Request (SRQ) will be generated at the completion of a measurement if the SRQ2 header is included with the TLK string. The following string will cause the Service Request to be generated when the power system has finished the power factor measurement.

```
TLK PWF SRQ2
```

3.7.26 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK VLT)

VLT may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output voltage with 0.1 volt resolution.

When VLT is used as a header in a string with no argument, it will cause the front panel to display the measured output voltage.

3.7.27 TO TALK THE MEASURED OUTPUT CURRENT (TLK CUR)

CUR may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output current in amps with 0.01 amp resolution for the 4500L-3P and 2750L-3P. The resolution is 0.1 amps for all other models.

When CUR is used as a header in a string with no argument, it will cause the front panel to display the output current.

TABLE 3-13

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
ALM	A B C	0000 *135.0 *270.0	Default voltage range code Low Voltage Range High Voltage Range
AMP	A,B,C	0 to 270.0	Programmed voltage Amplitude value in volts.
APW	A,B,C	0 to 2000 or 0.00 to 20.00	Output VA (4500L-3P and 2750L-3P) Output KVA (All other models)
CFG	A B C	0 to 30 * 28 * 120	IEEE-488 Listen Address Configuration Code Phase C initial Value
CLM	A B C	See MAX CURRENT TABLE 0 or 2 2 or 1	Defines the maximum current per phase Defines the power decimal point (0 = 4500L-3P and 2750L-3P, 2= all others) Defines the current decimal point (2 = 4500L-3P and 2750L-3P, 1 = all others)
CRL	A,B,C	0 to MAX CURRENT	Programmed output current limit.
CUR	A,B,C	0.00 to 20.0 or 0.0 to 100.0	Output current (4500L-3P and 2750L-3P) (All other models)
ELT	A B C	0000 to 9999 00 to 59 00 to 59	Total accumulated hours (H) Accumulated minutes (M) Accumulated seconds (S)
FLM	A B C	60 45 5000	Default frequency Low frequency limit High frequency limit
FQM	None	45.00 to 5000	Measured output frequency
FRQ	None	45.00 to 5000	Programmed frequency
INI	A C	0000 to 005.0 O to CRL	Default voltage Default current limit

(*) Standard values shown. Values will be different for other ranges, output power and options.

NOTE: If the A, B or C Extension is not sent with the argument, all phases will be reported.

TABLE 3-13 (continued)

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
SNC	None	INT or EXT	Programmed external sync mode
WVF	A, B, C	INT or EXT	Programmed waveform
PHZ	A, B, C	0.0 to 359.9	Programmed output phase angle
PWR	A, B, C	0 to 2000 or 0.00 to 27.00	Output watts (4500L-3P and 2750L-3P) Output KW (all other models)
PZM	A, B, C	0 to 359.9	Measured phase B and C output phase angle relative to A. A is always 0.0
REG	0 to 15	Contents of Reg	Talk contents of register
RNG	None	0 to 270.0	Programmed range and limit
SRQ	None	0, 1 or 2	Programmed SRQ status
VLT	A, B, C	0.0 to 400.0	Measured output voltage
THD	A, B, C	0 to 20	Programmed total harmonic distortion

NOTE: If the A, B or C Extension is not sent with the argument, all phases will be reported

VOLTAGE RANGE PAIR

MODEL	135/270	156/312	67.5/135	200/400
2750L-3P	7.40	6.40	14.82	5.00
2750L-1P	22.22	19.24	44.44	15.00
4500L-3P	12.34	10.68	24.70	8.34
4500L-1P	37.04	32.06	74.08	25.00
9000L/2-3P	24.68	21.36	49.38	16.66
9000L/2-2P	37.04	32.06	74.08	25.0
9000L/2-1P	74.08	64.12	148.2	50.0
13500L/3-3P	37.04	32.06	74.08	25.0
13500L/3-1P	111.2	96.18	222.2	75.0
27000L/6-3P	74.08	64.12	148.2	50.0
27000L/6-1P	222.2	192.4		150.0

MAX CURRENT

TABLE

TABLE 3-14

EXAMPLE TALK RESPONSE (3-PHASE SYSTEM)

ASCII STRING SENT		RESPONSE AFTER ADDRESSED TO TALK		
TLK	ALM	ALMA0000	B135.0	C270.0
TLK	AMP	AMPA000.0	B000.0	C000.0
TLK	APW	APWA1003	B0985	C1507
TLK	CFG	CFGA0001	B0028	C0120
TLK	CLM	CLMA11.12	B0002	C0000
TLK	CRL	CRLA11.12	B11.12	C11.12
TLK	CUR	CURA06.14	B05.12	C06.71
TLK	ELT	ELTH0147	M0051	S0033
TLK	FLM	FLMA0060	B0045	C0550
TLK	FQM	FQM59.97		
TLK	FRQ	FRQ60.00		
TLK	CLK	CLK INT (*)		
TLK	SNC	SNC INT		
TLK	PHZ	PHZA000.0	B240.0	C120.0
TLK	PWF	PWFA1.000	B1.000	C1.000
TLK	PWR	PWRA0.737	B0.620	C0.806
TLK	PZM	PZMA000.0	B242.1	C118.9
TLK	REG0	ACTUAL CONTENTS OF REGISTER 0		
TLK	RNG	RNGA 135.0	B135.0	C135.0
TLK	VLT	VLTA120.1	B119.8	C120.0
TLK	WVF	WVFA SNW	B SNW	C SNW (*)

(*) If function is not enabled, a syntax Error message will be generated

3.7.28 TO TALK THE MEASURED OUTPUT POWER (TLK PWR)

PWR may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output power in watts with 1 watt resolution for the 4500L-3P and 2750L-3P. The power is measured in kilowatts with 0.01 KW resolution for all other models.

When PWR is used as a header in a string with no argument, it will cause the front panel to display the output power.

3.7.29 TO TALK THE MEASURED OUTPUT POWER FACTOR (TLK PWF)

PWF may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the output power factor from 0 to 1.000.

When PWF is used as a header in a string with no argument, it will cause the front panel to display the output power factor.

3.7.30 TO TALK THE MEASURED OUTPUT APPARENT POWER (TLK APW)

APW may be used as an argument to the header TLK with an A, B or C extension. When used as an argument, it will set up the AC Power System to measure the Apparent Power output in VA with 1 VA resolution for the 4500L-3Pand 2750L-3P. The apparent power is measured in KVA with 0.01 KVA resolution for all other models.

When APW is used as a header in a string with no argument, it will cause the front panel to display the measured output Apparent Power.

3.7.31 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)

FQM may be used as an argument to the header TLK. There are no extensions for this argument. When FQM is used as an argument, it will set up the AC Power System to measure the output frequency in hertz.

When FQM is used as a header, it will cause the front panel to display the measured output frequency.

3.7.32 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM)

PZM may be used as an argument with an extension A, B or C for the header TLK. When used as an argument, PZM will set up the AC Power System to measure the phase angle of phase B and C relative to phase A. The measurement is made at the External Sense terminals. Phase A is the reference phase and will always be reported as 000.0 degrees unless the AC Power System is operating in the external sync mode.

When PZM is used as a header, it will cause the front panel to display the phase measurement screen.

3.7.33 MESSAGE SEPARATORS

A complete message consists of a header and an argument. Since more than one message can be sent in a setup string, message separators included in the string between the message will make it more readable to the human operator. Three message separators are recognized: the comma (,), semicolon (;) and a space. Since these separators are ignored, they may be dispersed throughout a setup string.

The following are two examples of ASCII strings with separators:

```
PHZA90;FRQ60;AMP115

CRL,90;FRQ50;AMP,120
```

3.7.34 SERVICE REQUEST

After power-up the GPIB Service Request (SRQ) will be generated after any error (example. syntax, output fault, etc.). This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1. Sending SRQ2 causes an SRQ to be generated after the execution of a setup string or when data is available after request of measurements. The setup string can be of any type: ramp, calibration, etc.

The following example disables GPIB SRQ.

```
SRQ0
```

3.7.35 SERIAL POLL STATUS BYTE

Once the bus controller has detected the SRQ, it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. The Status Byte values for various faults are given in Table 3-15.

3.7.36 END OF STRING

The End of String (EOS) delimiter recognized by the AC Power System is the ASCII Line Feed (LF). Carriage Return (CR) followed by Line Feed may also be used for EOS. The End or Identify (EOI) IEEE-488 message END will also be recognized. The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

3.7.37 ERROR MESSAGES

Table 3-15 shows all of the possible error messages that can be generated by the AC Power System. These messages will also be displayed on the front panel of the AC Power System.

3.7.38 GROUP EXECUTE TRIGGER

The trigger mode is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected, it will delay execution of the new setup values until the GPIB Device Trigger is sent by the bus controller.

A GPIB Device Trigger will also terminate a programmed ramp or other program.

The following setup string will recall the values from register 9 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. (See Table 3-10).

```
REC9TRG
```

TABLE 3-15

STATUS BYTE VALUES

SRQ 1	SRQ 0	REPORTED MESSAGE	CAUSE
64	0	AMP A FAULT	Overload or sense line fault
65	1	AMP B FAULT	Overload or sense line fault
66	2	AMP AB FAULT	Overload or sense line fault
67	3	AMP C FAULT	Overload or sense line fault
68	4	AMP AC FAULT	Overload or sense line fault
69	5	AMP BC FAULT	Overload or sense line fault
70	6	AMP ABC FAULT	Overload or sense line fault
71	7	CRL FAULT	Output current exceeds program value
72	8	TEMP A FAULT	Amplifier overtemperature
73	9	TEMP B FAULT	Amplifier overtemperature
74	10	TEMP AB FAULT	Amplifier overtemperature
75	11	TEMP C FAULT	Amplifier overtemperature
76	12	TEMP AC FAULT	Amplifier overtemperature
77	13	TEMP CB FAULT	Amplifier overtemperature
78	14	TEMP ABC FAULT	Amplifier overtemperature
90	26	RNG RANGE ERROR	RNG value greater than highest range
91	27	AMP RANGE ERROR	AMP value greater than RNG value
92	28	FRQ RANGE ERROR	FRQ value is less than 45 or greater than 2000 Hz
93	29	PHZ RANGE ERROR	PHZ value greater than ±999.0
94	30	CRL RANGE ERROR	CRL value greater than maximum value
95	31	RMPA RANGE ERROR	DLY, STP or VAL values wrong
96	32	SYNTAX ERROR	Wrong string SYNTAX
97	33	BUS LOCAL ERROR	Remote message sent while in local mode
98	34	EXT SYNC ERROR	No external sync input or signal not between 45 and 2000 Hz
99	35	CPU MEMORY FAULT	CPU failed self-test
100	36	DMA OVERFLOW ERROR	Remote message greater than 256 bytes
63			The response after SRQ2 is included in a setup string and the execution of the string or measurement is completed.
	40	STA OK	No problems

TABLE 3-16

HP SERIES 80 CONTROLLER STATEMENTS

CLEAR	Universally sets all instruments to their power-on states by sending the GPIB message DCL.
CLEAR 701	Sets only instrument with listen address "1" to its power-on state by sending the GPIB message SDC.
LOCAL 7	Universally sets all instruments into their local control mode by deasserting REN.
LOCAL 701	Sets only instrument with listen address "1" to its local control mode by sending the GTL message.
LOCAL LOCKOUT 7	Universally sets all instruments to disable their local control.
REMOTE 7	Sets REN true.
REMOTE 701	Sets instrument with listen address "1" to remote.
ABORTIO 7	Clears all instrument interfaces to unlisten and untalk by toggling IFC.
RESUME 7	Sets ATN false.
OUTPUT 701; "AMP"; V	Sends the data string AMP followed by the numerical value of variable V to the instrument with listen address "1".
STATUS 7,1;A	This statement reads the SR1 register of the series 80 controller for the interrupt cause. This statement is necessary to clear the Service Request flag in the controller.
ENABLE INTR	This statement allows the series 80 controller program to be interrupted when a GPIB instrument generates SRQ.
ON INTR 7 GOSUB100	This statement causes the program to go to an interrupt subroutine at 100.
TRIGGER 7	This statement triggers all addressed instruments by sending the GET message.
TRIGGER 701	This statement triggers only the instrument with listen address "1" by sending the GET message.
A=SPOLL (7)	Sets variable A equal to the decimal value of the Status Byte of an instrument previously addressed to talk.
A=SPOLL (701)	Sets variable A equal to the decimal value of the Status Byte of the instrument with listen address "1".

3.7.39 HEWLETT PACKARD SERIES 80 PROGRAM EXAMPLES

For the following program examples, the listen address is "1" and the controller interface is select code "7".

Table 3-16 lists some of the Series 80 Controller statements that may be useful in programming the AC Power System on the GPIB. For additional statements and their descriptions, refer to the Hewlett Packard I/O programming guide for the series 80 Computer.

The following program will step the program voltage from 0 volt to 130 volts in .1 volt steps:

```
10 REMOTE 7
20 FOR V=0 TO 130 STEP .1
30 OUTPUT 701; "AMP"; V
40 NEXT V
50 END
```

The following program will load the parameters of 115 volts and 400 hertz. The Model AC Power System will output the parameters only after the K1 special function key of the Series 80 Controller is depressed to send the GET message.

```
10 REMOTE 701
20 OUTPUT 701 ; "AMP115 FRQ 400 TRG"
30 ENABLE KBD 32+64 ! ENABLE PAUSE AND SPECIAL FUNCTION KEYS
40 ON KEY # 1 GOTO 100 ! USE KEY K1 FOR DEVICE TRIGGER
50 GOTO 40

100 TRIGGER 701
110 END
```

The program example for SRQ uses the statements STATUS, ON INTR, ENABLE INTR, AND SPOLL.

The STATUS statement in line 20 is necessary to clear the Controller status register from any possible previous Service Request (SRQ) interrupts. The HP I/O Programming Manual is not clear on the use of the STATUS statement but it must be used after every SRQ and before enabling or reenabling the SRQ interrupt to prevent false SRQ indication. Line 30 causes the program to go to the interrupt subroutine at line 100.

The ENABLE INTR statement in line 40 enables the SRQ to generate an interrupt. A setup string in line 60 causes an SRQ to be generated. The SRQ interrupt subroutine is between lines 100 and 150.

The STATUS statement in line 120 clears the SRQ.

Line 130 generates a Status Byte from the AC Power System with listen/talk address "1".

```
10  REMOTE 701 ! PUT INSTRUMENT#1 INTO REMOTE
20  STATUS 7,1,;Z! READ STATUS TO CLEAR HP SERIES 80 STATUS
    REGISTER.
30  ON INTR 7 GOSUB 100! ON SRQ GO TO ROUTINE AT LINE 100.
40  ENABLE INTR 7;8! ENABLE HP SERIES 80 FOR SRQ INTERRUPT.
50  ! THE FOLLOWING SETUP STRING WILL GENERATE AN SRQ AFTER COM-
    PLETION.
60  OUTPUT 701; AMP105 DLY10 VAL115 SRQ2.
70  WAIT 20000!
80  DISP "SETUP STRING DIDN'T GENERATE AN SRQ".
90  END
100 ! SERVICE REQUEST FOR DEVICE 1
110 ! USE SERIAL POLL TO DETERMINE STATUS BYTE
120 STATUS 7,1;Z ! READ STATUS TO CLEAR SRQ
130 A=SPOLL (701)
```

3.8 REMOTE OPERATION WITH MATE CIIL

The 4500L-3P and 2750L-3P are the only Power System configuration with the MATE CIIL option. When the 4500L-3P or the 2750L-3P is configured to operate with CIIL as the principal language, the alternate language is APE. Refer to Section 3.7 for information on the APE program syntax. Using CIIL, the power source will accept OP codes, the noun ACS (AC SIGNAL) and noun modifiers to program the operating parameters of voltage, frequency, phase and current limit in a setup string. In addition, a number of OP codes cause the power source to perform a specific task such as reset and confidence testing. Figure 3-6 is a summary of the CIIL program syntax.

3.8.1 CIIL ELEMENTS

The Control Interface Intermediate Language (CIIL) elements are:

OP-CODES:	FNC, SET, SRX, SRN, CLS, OPN, RST, CNF, IST, INX, FTH, STA, GAL
NOUN:	ACS
NOUN MODIFIERS:	VOLT, FREQ, PANG, CURL, SYNI, POWR, APOW, CURR, TRSC
CHANNEL DESIGNATORS	:CH00, :CH01, :CH02, :CH03

The only noun recognized by the power source is ACS for AC Signal. The only non-operational code (no-op) in a string is an ASCII space. Numeric expressions may be represented by explicit decimal values (e.g., 115.0) or exponential values (e.g., 0.115E3). The exponent field may be either a one-digit or two-digit form (e.g., E1 or E01) signed or unsigned with a range from E-24 to E+24.

STIMULUS STRING

```
                                                        *
FNC-->-ACS->---->:CH00->----->SET->------>VOLT->-----<value>-<CR>
<LF>
               ->:CH01->    ->SRX->     ->FREQ->
               ->:CH02->    ->SRN->     ->PANG->
               ->:CH03->                ->CURL->
                                        ->SYNI->
*NOTE:  There is no value for SET SYNI


RST---->ACS---->---->:CH00->---<CR><LF>
                   ->:CH01->
                   ->:CH02->
                   ->:CH03->


-->---->CLS->_____>:CH00->---<CR><LF>
      ->OPN->     ->:CH01->
                  ->:CH02->
                  ->:CH03->
```

GENERAL CIIL STRINGS

```
-->---->GAL->---><CR><LF>
      ->CNF->
      ->IST->
      ->STA->
```

SENSOR STRINGS

```
    FNC---->ACS-->---->VOLT->---------->:CH00->------<CR><LF>
    RST--             ->FREQ->         ->:CH01->
                      ->PANG->         ->:CH02->
                      ->CURR->         ->:CH03->
                      ->APOW->
                      ->POWR->

    ------>INX->------>VOLT->------<CR><LF>
         ->FTH->     ->FREQ->
                     ->PANG->
                     ->CURR->
                     ->APOW->
                     ->POWR->
```

FIGURE 3-6

CIIL PROGRAM SYNTAX

3.8.2 Channel Designators

The channel designator consists of a colon (:) followed by the syntax CH and a single-digit or two-digit channel number. The general form for the channel designator is CHnn and may be any of the following;

```
:CH00  Designates all outputs.
:CH01  Designates Phase A.
:CH02  Designates Phase B.
:CH03  Designates Phase C.
```

Channel designators and their applicable noun modifiers are listed in Table 3-17.

3.8.3 OP-Codes

Each of the OP-codes listed is described in following paragraphs.

3.8.3.1 FNC

All set-up strings must begin with OP-code FNC followed by the noun ACS, and the channel designator :CHnn (e.g., FNC ACS :CH03).

3.8.3.2 SET

The SET (set-up) OP-code must be sent when a characteristic included in the output string is to be programmed. The noun modifiers that may follow the SET OP-code are VOLT, FREQ, SYNI, CURL, TRSC and PANG. A SET OP-code is always followed by a noun modifier. A SET string has the following string elements:

```
FNC ACS :CHnn SET<NOUN-MOD><NUMERIC> <CR> <LF>
```

An example of a setup string where the phase A output is set to 115.0 volts is as follows:

```
FNC ACS :CH01 SET VOLT 115.0 <CR><LF>
```

Note that all strings end with ASCII <CR><LF>. The power source is configured to recognize this series of ASCII characters as indicating end-of-string (EOS).

TABLE 3-17

CHANNEL DESIGNATORS AND NOUN MODIFIERS

CHANNEL DESIGNATOR	MODIFIER	FUNCTION
:CH00	VOLT	Simultaneously set amplitude for Phase A, Phase B and Phase C
:CH01	VOLT	Set Phase A Amplitude
:CH02	VOLT	Set Phase B Amplitude
:CHO3	VOLT	Set Phase C Amplitude
:CH00	FREQ	Set Frequency
:CH01	FREQ	Set Frequency
:CH02	FREQ	Set Frequency
:CH03	FREQ	Set Frequency
:CH00	PANG	Syntax error with :CH00
:CH01	PANG	Set Phase A phase angle
:CH02	PANG	Set Phase B phase angle
:CH03	PANG	Set Phase C phase angle
:CH00	CURL	Simultaneously set Phase A, Phase B and Phase C current limit.
:CH01	CURL	Set Phase A current limit
:CH02	CURL	Set Phase B current limit
:CH03	CURL	Set Phase C current limit
:CH00	SYNI	Set sync to external signal
:CH00	POWR	Send power measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	POWR	Send power measurement data for Phase A to Bus controller
:CH02	POWR	Send power measurement data for Phase B to Bus Controller
:CHO3	POWR	Send power measurement data for Phase C to Bus Controller
:CH00	APOW	Send apparent power measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	APOW	Send apparent power measurement data for Phase A to Bus Controller
:CH02	APOW	Send apparent powr measurement data for Phase B to Bus controller
:CH03	APOW	Send apparent power measurement data for Phase C to Bus Controller
:CH00	CURR	Send output current measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	CURR	Send output current measurement data for Phase A to Bus Controller
:CH02	CURR	Send output current measurement data for Phase B to Bus Controller
:CH03	CURR	Send output current measurement data for Phase C to Bus Controller

3.8.3.3 SRX and SRN OP-Codes

The SRX (set maximum) OP-code sets the maximum value of the programmable noun modifiers VOLT, FREQ, PANG and CURL. It is always accompanied by a noun modifier. An example of setting the maximum output amplitude of all phases to 135 volts and the output to 115 volts follows:

```
FNC ACS :CH00 SRX VOLT 135 SET VOLT 115.0 <CR> <LF>
```

The SRN OP-code sets the minimum value. For example, to set the minimum value of the output amplitude to 5.0 volts and the output to 20 volts, the following string is transmitted:

```
FNC ACS :CH00 SRN VOLT 5 SET VOLT 20 <CR> <LF>
```

3.8.3.4 OPN and CLS

The CLS (Close) OP-code closes the relay between the amplifier outputs and the output connector. The CLS Op-code must be followed by a valid channel designator. (:CH00, :CH01, :CH02 or :CH03), but all channels close simultaneously for any valid designator. A programmed amplitude will not be generated at the output of the power source until the relays have been closed.

```
CLS :CH00 <CR> <LF>   Closes relay
```

If an output voltage been programmed prior to the CLS OP-code, the output will appear after CLS has been sent. If the power source has the MT option, do not program a voltage greater than 30 volts without closing the output relays or the confidence loads in the power source may be damaged.

The OPN (open) OP-code opens the relay at the power source output. Prior to opening the relay, the output of the power source is reduced to zero.

```
OPN :CH00 <CR> <LF>   Opens relay
```

3.8.3.5 RST

The RST (reset) OP-code resets the power source to its default values as follows:

Output Amplitude	5.0 Volts
Frequency	Selected default frequency
Phase A Phase Angle	0 Degrees*
Phase B Phase Angle	240 Degrees
Phase C Phase Angle	120 Degrees
Sync	Internal
Current Limits	Maximum current of power system
Power Source Relays	Open

*Relative to External Sync.

In addition, all non-catastrophic error messages (SYNTAX and RANGE errors) are cleared. All other error messages are not affected.

OP-code RST must be followed by ACS and any one of the valid channel designators :CH00 through :CH03 (e.g., RST ACS :CH00 <CR> <LF>).

3.8.3.6 CNF and IST

The CNF (confidence) OP-code instructs the power source to perform a confidence test of the entire power system. The OP-code stands by itself. The confidence test flow diagram is shown in Figure 3-7. If confidence testing detects a fault, an appropriate message is transmitted to the Bus Controller on receipt of an STA OP-code (see paragraph 3.8.3.9). The output relays of the power source are opened during confidence testing.

During confidence testing, the power source generates the following:

Amplitude A, B, C	115 Volts
Frequency	400 Hz
Current Limit	Maximum and 5% of Maximum
B Phase Angle	240 degrees
C Phase Angle	120 degrees

The power source compiles a message after the confidence test and the receipt of a STA OP-code. The power source responds with the appropriate message as shown in Figure 3-7. The reference designators shown in Figure 3-6 are for the subassemblies most likely to be at fault.

The IST (internal self test) OP-code produces the same response described for CNF.

3.8.3.7 INX

The INX (initialize) OP-code is a request for data from the power source. A request for the time required to measure the voltage of all phases consists of the following strings:

```
FNC ACS VOLT :CHnn <CR> <LF>
INX VOLT <CR> <LF>
```

The power source then responds with:

```
<SP> 5 <CR> <LF>
```

The power source response indicates that 5 seconds will be required to perform the measurement. The measurement time values are stored in read-only memory in the power source.

Note that the INX OP-code must be preceded by an FNC OP-code string containing the noun modifier for which INX will request data.

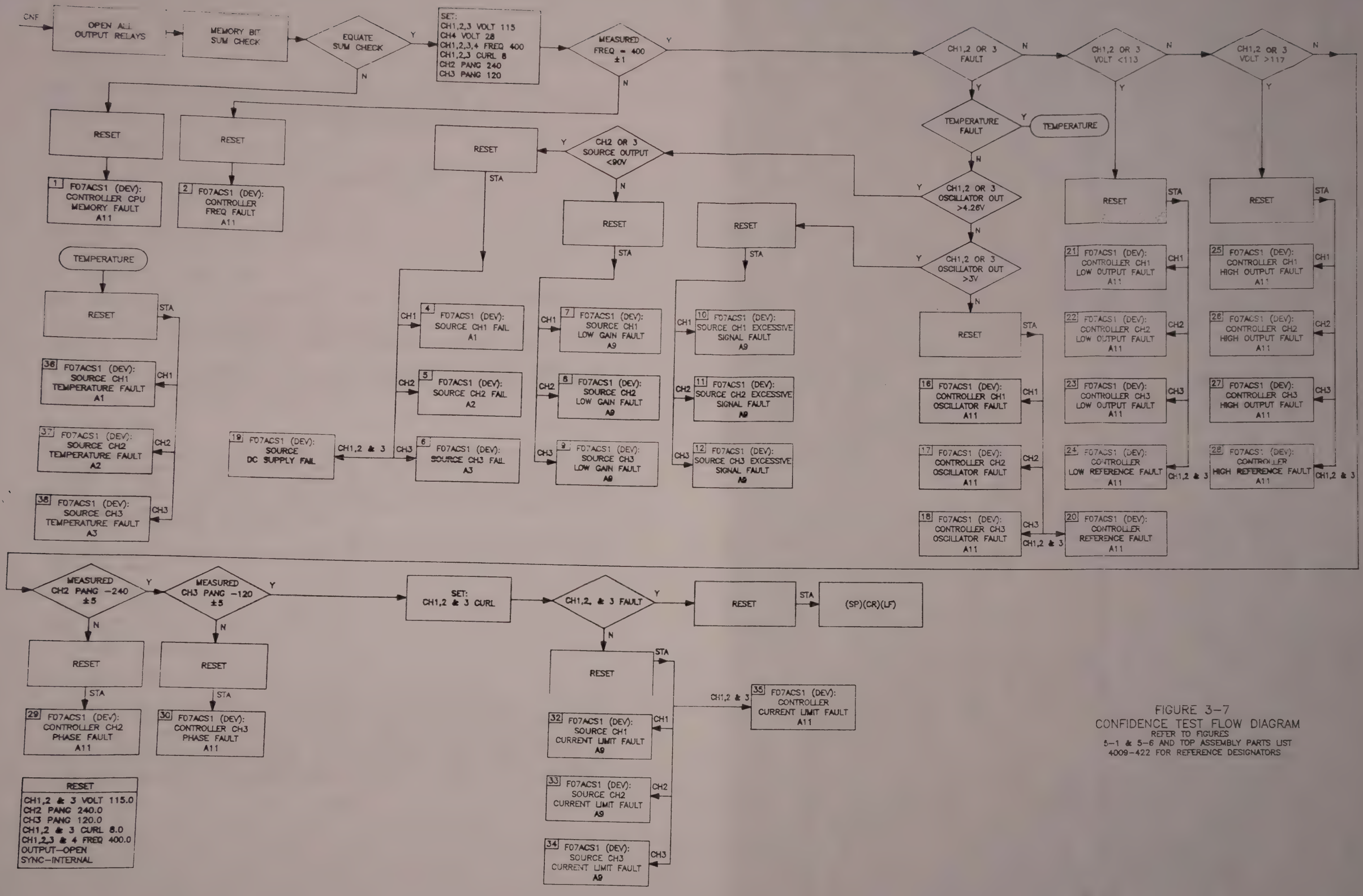

CNF
OPEN ALL OUTPUT RELAYS
MEMORY BIT SUM CHECK
EQUATE SUM CHECK
Y
N
SET:
CH1,2,3 VOLT 115
CH4 VOLT 28
CH1,2,3,4 FREQ 400
CH1,2,3 CURL 8
CH2 PANG 240
CH3 PANG 120
MEASURED FREQ = 400 ±1
CH1,2 OR 3 FAULT
CH1,2 OR 3 VOLT <113
CH1,2 OR 3 VOLT >117
TEMPERATURE FAULT
TEMPERATURE
CH1,2 OR 3 OSCILLATOR OUT >4.26V
CH1,2 OR 3 OSCILLATOR OUT >3V
CH2 OR 3 SOURCE OUTPUT <90V
RESET
STA
1 F07ACS1 (DEV): CONTROLLER CPU MEMORY FAULT A11
2 F07ACS1 (DEV): CONTROLLER FREQ FAULT A11
4 F07ACS1 (DEV): SOURCE CH1 FAIL A1
5 F07ACS1 (DEV): SOURCE CH2 FAIL A2
6 F07ACS1 (DEV): SOURCE CH3 FAIL A3
7 F07ACS1 (DEV): SOURCE CH1 LOW GAIN FAULT A9
8 F07ACS1 (DEV): SOURCE CH2 LOW GAIN FAULT A9
9 F07ACS1 (DEV): SOURCE CH3 LOW GAIN FAULT A9
10 F07ACS1 (DEV): SOURCE CH1 EXCESSIVE SIGNAL FAULT A9
11 F07ACS1 (DEV): SOURCE CH2 EXCESSIVE SIGNAL FAULT A9
12 F07ACS1 (DEV): SOURCE CH3 EXCESSIVE SIGNAL FAULT A9
16 F07ACS1 (DEV): CONTROLLER CH1 OSCILLATOR FAULT A11
17 F07ACS1 (DEV): CONTROLLER CH2 OSCILLATOR FAULT A11
18 F07ACS1 (DEV): CONTROLLER CH3 OSCILLATOR FAULT A11
19 F07ACS1 (DEV): SOURCE DC SUPPLY FAIL
20 F07ACS1 (DEV): CONTROLLER REFERENCE FAULT A11
21 F07ACS1 (DEV): CONTROLLER CH1 LOW OUTPUT FAULT A11
22 F07ACS1 (DEV): CONTROLLER CH2 LOW OUTPUT FAULT A11
23 F07ACS1 (DEV): CONTROLLER CH3 LOW OUTPUT FAULT A11
24 F07ACS1 (DEV): CONTROLLER LOW REFERENCE FAULT A11
25 F07ACS1 (DEV): CONTROLLER CH1 HIGH OUTPUT FAULT A11
26 F07ACS1 (DEV): CONTROLLER CH2 HIGH OUTPUT FAULT A11
27 F07ACS1 (DEV): CONTROLLER CH3 HIGH OUTPUT FAULT A11
28 F07ACS1 (DEV): CONTROLLER HIGH REFERENCE FAULT A11
29 F07ACS1 (DEV): CONTROLLER CH2 PHASE FAULT A11
30 F07ACS1 (DEV): CONTROLLER CH3 PHASE FAULT A11
32 F07ACS1 (DEV): SOURCE CH1 CURRENT LIMIT FAULT A9
33 F07ACS1 (DEV): SOURCE CH2 CURRENT LIMIT FAULT A9
34 F07ACS1 (DEV): SOURCE CH3 CURRENT LIMIT FAULT A9
35 F07ACS1 (DEV): CONTROLLER CURRENT LIMIT FAULT A11
36 F07ACS1 (DEV): SOURCE CH1 TEMPERATURE FAULT A1
37 F07ACS1 (DEV): SOURCE CH2 TEMPERATURE FAULT A2
38 F07ACS1 (DEV): SOURCE CH3 TEMPERATURE FAULT A3
CH1
CH2
CH3
CH1,2 & 3
MEASURED CH2 PANG −240 ±5
MEASURED CH3 PANG −120 ±5
SET: CH1,2 & 3 CURL
CH1,2, & 3 FAULT
(SP)(CR)(LF)
RESET
CH1,2 & 3 VOLT 115.0
CH2 PANG 240.0
CH3 PANG 120.0
CH1,2 & 3 CURL 8.0
CH1,2,3 & 4 FREQ 400.0
OUTPUT—OPEN
SYNC—INTERNAL

FIGURE 3-7
CONFIDENCE TEST FLOW DIAGRAM
REFER TO FIGURES
5-1 & 5-6 AND TOP ASSEMBLY PARTS LIST
4009-422 FOR REFERENCE DESIGNATORS

3.8.3.8 FTH

The FTH (fetch) OP-code function fetches data from the power source for the parameter indicated by the noun modifier of the previous string. For example, the following FNC string is first sent:

FNC ACS VOLT :CH01 <CR> <LF>

Then the measurement value is requested with:

FTH VOLT <CR> <LF>

Assuming that the output of phase A is 115.5 volts, the power source responds with:

<SP> 115.5 <CR> <LF>

The FTH OP-code may be repeated for the same FNC noun modifier.

An INX string may be inserted between the two strings as described in 3.8.3.7, if the time to accomplish the measurement is required.

If the channel indicator in the above example had been :CH00, the power source would have responded with the values of all three phases in the order of A, B and C.

3.8.3.9 STA

The STA (status) OP-code instructs the power source to transfer its output message to its output buffer. The message is then transmitted to the Bus Controller when the power source is addressed to talk. Table 3-18 lists all of the possible status messages generated outside of confidence testing. All confidence testing messages are shown in Figure 3-7.

If the power source is operating correctly and the following OP-code is sent:

STA <CR> <LF>

The power source responds with:

<SP> <CR> <LF>

3.8.3.10 GAL

The GAL (go to alternate language) OP-code instructs the power source to discontinue use of the CIIL language and start accepting commands in the Abbreviated Plain English (APE) language. While operating in the APE language mode, sending ASCII characters CIIL will return operation to the CIIL language. When power is removed and then restored, the power source reverts to the native language.

TABLE 3-18

NON-CNF STATUS MESSAGES

CONDITION	DEVICE RESPONSE
Loaded output Fault	F07ACS01 <SP> (DEV): <SP>OUTPUT CH01/02/03 VOLT FAULT <CR><LF>
Source Temperature Fault	F07ACS01 <SP> (DEV): <SP> SOURCE CH01/02/03 TEMPERATURE <CR><LF>
Program out of range for VOLT, FREQ, PANG or CURL	F07ACS01 <SP> (MOD): <SP> VOLT/FREQ/PANG/CURL RANGE ERROR <CR> <LF>
Unrecognizable OP-code or missing OP-code	F07ACS01 <SP> (MOD): <SP>SYNTAX ERROR <CR><LF>
Good Status	<SP><CR><LF>

3.8.4 Noun Modifiers

Noun modifiers are a CIIL mnemonic indicating the characteristic of the signal to be described.

3.8.4.1 Volt

The VOLT (voltage) noun modifier may be contained in a string as an instruction to the power source with SET, SRX or SRN. Depending on the OP-code, an output voltage (or voltages) may be programmed or set as an upper or lower limit in 0.1-volt increments up to the range limit. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the amplitude to be programmed. For example, to set the output voltage of all three phases to 110 volts, the following string is transmitted:

```
FNC ACS :CH00 SET VOLT 110 <CR> <LF>
```

The noun modifier may also be used in a string that uses the sensor (measurement) capability of the power source. An example of requesting the measurement of power source phase A output voltage follows. Note that the noun modifier precedes the channel indicator.

```
FNC ACS  VOLT :CH01 <CR> <LF>
FTH VOLT <CR> <LF>
```

When the output voltage of phase A is 110.0 the power source responds with:

<SP> 110.0 <CR> <LF>

3.8.4.2 FREQ

The FREQ (frequency) noun modifier may be contained in a string as an instruction to the power source with SET, SRX or SRN. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. Any one of the four channel indicators may be used in the string. The number which follows the modifier in the string determines the frequency to be programmed. For example, to program all phases to 440 Hertz, the following string is transmitted:

FNC ACS :CH00 SET FREQ 440 <CR><LF>

The FREQ modifier may also be used to instruct the power source to measure the output frequency as follows. Note that the noun modifier precedes the channel indicator:

FNC ACS FREQ :CH00 <CR><LF>

Followed by string:

FTH FREQ <CR> <LF>

The response from the power source when the frequency is 380.0 Hz is then:

<SP> 380.0 <CR> <LF>

3.8.4.3 PANG

The PANG (phase angle) noun modifier may be contained in a string as an instruction to the power source with SET, SRX or SRN. Depending on the OP-code, an output phase angle (or phase angles) may be programmed or the upper or lower limit set in one-tenth degree increments. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the phase angle to be programmed.

FNC ACS :CH02 SET PANG90 <CR> <LF>

As with the FREQ and VOLT modifiers, the INX OP-code may be used to request time for PANG measurement:

FNC ASC PANG :CH02 <CR><LF>
INX PANG :CH01 <CR> <LF>)

When addressed to talk, the power source responds with the maximum time required to make the measurement in seconds:

<SP> 5 <CR> <LF>

When operating in the external sync mode, the phase angle of phase A relative to the external sync input may be programmed as follows:

FNC ASC :CH01 SET PANG90 SET SYNI <CR><LF>

The phase A output will still track the SYNC input, but will be offset by 90 degrees. The phase angles of phases B and C will still be relative to phase A.

3.8.4.4 CURL

The CURL (current limit) noun modifier may be contained in a string as an instruction to the power source with SET, SRX or SRN. Depending on the OP-code, an output current limit (or limits) may be programmed or set as to upper or lower limit in or 0.01 ampere increments up to the power source maximum current. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the current limit to be programmed.

FNC ACS :CH00 SET CURL 2.5 <CR> <LF>

3.8.4.5 SYNI

SET SYNI enables the external SYNC input. The power source returns to the internal sync mode in the absence of the SYNI noun modifier from any set-up string. Any channel indicator may be used in the set-up string that includes SYNI. SYNI may be used with PANG to program the phase A phase angle relative to the sync signal. The following string enables the power source to track the frequency and phase of the external sync signal:

FNC ACS :CH00 SET SYNI <CR> <LF>

Note that other noun modifiers may be included in the above string.

While operating in the external synchronize mode, the power source tracks the frequency and phase of the external signal. Note that its phase may be offset from the SYNC input (see paragraph 3.8.4.3). The frequency of the external signal is reported with the following set of strings:

(L) FNC ACS FREQ :CH00 <CR> <LF>
(L) INX FREQ <CR> <LF>
(T) <SP> "default time-out value reported"<CR><LF>
(L) FTH FREQ <CR><LF>
(T) <SP> "measured value of external sync frequency reported" <CR> <LF>

In the above, (L) indicates the power source is listen addressed and (T) that it is talk addressed. The INX OP-code in the above series of strings may be omitted if the time data is not required.

3.8.4.6 CURR

The CURR (current measurement) noun modifier's single function is to measure current. The strings to initiate the current measurement of Phase B are as follows:

```
FNC ACS CURR :CH02 <CR> <LF>
FTH CURR <CR> <LF>
```

The current of Phase A, B or C can be measured with channel designators :CH01, :CH02 or :CH03, respectively.

3.8.4.7 POWR

Noun modifier POWR (power measurement) is included in a string to instruct the power source to measure the power output of the power source. The strings to initiate the power measurement are as follows:

```
FNC ACS POWR :CH01 <CR> <LF>
FTH POWR <CR> <LF>
```

The response from the power source is:

```
<SP> 80.5 <CR> <LF>
```

The foregoing assumes an output power on phase A of 80.5 watts. The power of either Phase A, B or C may be measured.

3.8.4.8 APOW

Noun modifier APOW (apparent power measurement) included in a string instructs the power source to measure the apparent power output of the power source in volt-amperes (VA). The strings to initiate the measurement are as follows:

```
FNC ACS APOW :CH01 <CR> <LF>
FTH APOW <CR> <LF>
```

The response from the power source is:

```
<SP> 65.5 <CR> <LF>
```

The foregoing assumes an apparent output power on phase A of 65.5 VA.

3.8.5 NORMAL CONDITION RESPONSES

All normal condition responses of the power source to requests from the bus controller (either status or measurement requests) begin with an ASCII space <SP>. In the following examples of bus controller/power source exchange, (L) indicates the power source is listen addressed and (T) indicates it is talk addressed.

When the power source is requested to measure one of the parameters identified by a noun modifier (e.g., VOLT), the following strings are sent and received by the bus controller:

(L) FNC ACS VOLT :CH01 <CR> <LF>
(L) INX VOLT <CR> <LF>
(T) <SP> "default time out" <CR> <LF>
(L) FTH VOLT <CR> <LF>
(T) <SP> 115.5 <CR> <LF>

When the power source receives an STA OP-code after a CNF OP-code, its normal response is an ASCII space <SP>. An example of the strings transmitted and received is:

(L) CNF <CR> <LF>
(L) STA <CR> <LF>
(T) <SP> <CR ><LF>

The power source accepts the STA OP-code after any string which is sent to it. For example:

(L) FNC ACS :CH00 SET VOLT115 SRX VOLT 135 SRN VOLT5 <CR><LF>
(L) STA
(T) <SP> <CR> <LF>

3.8.6 ABNORMAL CONDITION RESPONSE

When an abnormal condition has been detected by the power source, its response to the STA OP-code will begin with an ASCII F. The abnormal condition may be in the power source or specifically in the power source controller. In the examples that follow, (MOD) is an abbreviation for MODULE and refers to the power controller; (DEV) is an abbreviation for DEVICE and refers to the power source excluding the power controller. The response string for an abnormal condition is:

F07ACS01 <SP> (DEV): <SP> "message"<CR> <LF>

The status contained in "message" may be similar to the following:

```
OUTPUT CH01&02&03 VOLT FAIL
OUTPUT CH01&02&03 TEMPERATURE FAIL
CONTROLLER CH01&02&03 FREQ FAIL
```

Where a & means "and".

When an STA OP-code is transmitted after any string, the complete abnormal response may be similar to:

```
F07ASC01 <SP> (MOD) : <SP>"message"<CR> <LF>
```

The status contained in "message" may be any of the following for non-CNF messages:

```
SYNTAX ERROR
VOLT RANGE ERROR
FREQ RANGE ERROR
CURL RANGE ERROR
PANG RANGE ERROR
```

The response of the power source under a short circuit condition is as follows:

```
F07ACS01<SP>(DEV): <SP> OUTPUT CH01&02&03 VOLT FAULT <CR> <LF>
```

A setup string can always be followed by another string with the STA OP-code. In the event of a syntax, range or system error, an error message will be returned to the bus controller when the power source is addressed to talk. The value of the last parameter in a setup string is the one displayed on the front panel of the power source.

3.8.7 DISCRETE FAULT INTERRUPT

A discrete fault condition is one that would pose a hazard to equipment or personnel. A Discrete Fault Interrupt (DFI) is supplied with the MT power source option. The DFI relay contacts are connected to the BNC connector, J3, on the power source rear panel. Under normal operating conditions, the DFI relay contacts are open; when a fault is detected, the contacts close. The user may connect any type of indicator or alarm circuit to the DFI connector provided the applied signal is limited to 0.1 amps and 26 volts.

The conditions which will cause the discrete fault interrupt are listed in Table 3-19.

TABLE 3-19

DISCRETE FAULT INTERRUPT CONDITIONS

FAULT	CONDITION
OVERLOAD OUTPUT	The full rated power capability is exceed on any phase where programmed output voltage is not maintained.
PROGRAMMABLE CURRENT	The load draws more current than the programmed current limit point on any phase.
OVERTEMPERATURE	Excess heatsink temperature in power supply or output amplifier due to high ambient temperature or internal component failure.
CONTROLLER FAILURE	The AC Power Controller has a CPU failure which is monitored by a watch dog timer.
POWER OFF	Power remains off - input breaker off.

3.8.8 PROGRAM EXAMPLES

Table 3-20 lists some typical CIIL strings. Each one illustrates the versatility in programming which is a feature of the power source. The strings listed transmit the information with the fewest possible characters. Decimal points need not be included when followed by zeros. Spaces may not be included anywhere in the string.

TABLE 3-20

SAMPLE PROGRAMMING STRINGS

PROGRAM	STRING
All three phase to 115 volts and current limit to 2 amperes and enable external sync	FNC ACS :CH00 SET CURL2 SET FREQ400 SET VOLT 115 SET SYNI <CR><LF>
Phase B to 100 volts and current limit to 2 amps	FNC ACS :CH02 SET CURL.2E1 SET FREQ4E2 SET VOLT100 <CR><LF>
To power-up state open relay	RST ACS :CH00 <CR><LF>
Phase B to 90 degrees	FNC ACS :CH02 SET PANG90 <CR><LF>
Freq. to 65.23 Hz	FNC ACS :CH00 SET FREQ65.23 <CR><LF>
All three phases to 2.5 amps average current limit	FNC ACS :CH00 SET CURL2.5 <CR><LF>
Phase C current limit to 2 amps average	FNC ACS :CH03 SET CURL2 <CR><LF>
Confidence test	CNF <CRL><LF>
For status msg	STA <CR><LF>
Output relay closed	CLS :CH00 <CR><LF>
To measure output voltage only of Phase A	FNC ACS VOLT :CH01 <CR><LF>
Output relay opened	OPN :CH00 <CR><LF>
To measure Freq.	FNC ACS FREQ :CH00 <CR><LF> FTH FREQ <CR><LF>
To measure output voltage of all phases	FNC ACS VOLT <CR><LF>
Query time of measurement of voltage	FNC ACS VOLT <CR1><LF> INX VOLT <CR><LF>

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 4

CALIBRATION PROCEDURE

4.1 GENERAL

The calibration is divided into two categories; a periodic and a nonperiodic calibration. The periodic calibration should be performed at a 1 year interval. The nonperiodic calibration should only be performed if the periodic calibration cannot be performed or if an adjustable subassembly is replaced.

The following is a listing of paragraphs that may be performed to fix an indicated problem. Any AC Power System with a 1-phase output or that has more than one chassis will have paralleled amplifiers.

PARAGRAPH	TITLE
4.3.1	OUTPUT VOLTAGE CALIBRATION
	This is a periodic calibration of the output voltage.
4.3.2	VOLTAGE MEASUREMENT CALIBRATION
	This is a periodic calibration of the voltage measurement function.
4.3.3	CURRENT MEASUREMENT CALIBRATION
	This is a periodic calibration of the current measurement function.
4.3.4	POWER MEASUREMENT CALIBRATION
	This is a calibration of the power measurement function.
4.3.5	REMOTE MEASUREMENT CALIBRATION
4.4.1	OUTPUT FREQUENCY CALIBRATION
	This is a nonperiodic calibration of the output frequency.
4.4.2	AMPLIFIER GAIN BALANCE ADJUSTMENT
	These are nonperiodic adjustments of the output amplifier assembly 4009-423. The adjustments may have to be performed for the following reasons:

1. An output amplifier has been repaired.

2. For all power systems except 4500L-3P and 2750L-3P, unable to obtain rated output current.

3. There is an output current from an amplifier used in any power system, except 4500L-3P and 2750L-3P, when there is no load on the system output.

4.4.3 CURRENT TRANSFORMER ADJUSTMENT

These are nonperiodic adjustments. The adjustments are required if it is impossible to perform the current or power measurement calibration (Ref. Paragraph 4.3.3 and/or 4.3.4).

4.4.4 LOAD BALANCE ADJUSTMENT

This is a nonperiodic adjustment. The adjustment is required if the rated output current is not available from an AC Power System.

4.4.5 CURRENT LIMIT CALIBRATION

This is a nonperiodic calibration. The calibration is required if the available output current is not equal tc the programmed current limit value. The available output current may exceed the programmed value by 10%.

4.4.6 OUTPUT PHASE ANGLE CALIBRATION

This is a nonperiodic calibration. The calibration is required if there is an error in the phase B or C output phase angle relative to phase A.

4.2 TEST EQUIPMENT

The following equipment or their equivalents are required to completely test the AC Power System.

TEST EQUIPMENT FOR PERIODIC CALIBRATION

1. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent.

2. 100 Amp Current Transformer: Pearson Model 3468

3. Resistive Loads: See LOAD RES value from Table 4-1

ADDITIONAL TEST EQUIPMENT

1. Two additional Digital Voltmeters
2. Frequency Counter: Philips PM 6671
3. Phase Angle Meter: Krohn-Hite 6500A

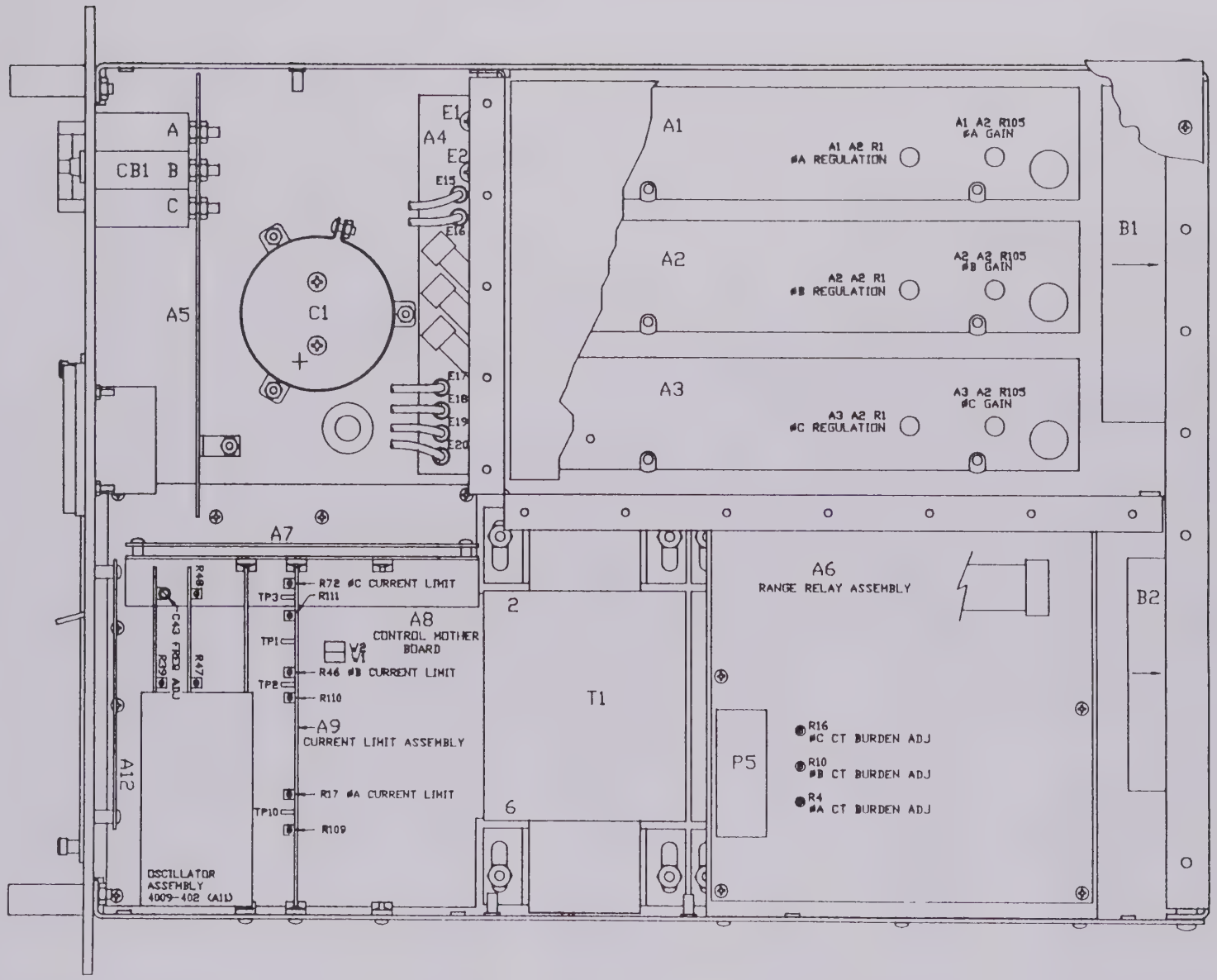


FIGURE 4-1

INTERNAL ADJUSTMENTS AND JUMPER LOCATIONS

	MODEL	4500L/1-3	9000L/2-3	4500L/1-1 9000L/2-2 13500L/3-3	9000L/2-1 27000L/6-3	13500L/3-1	27000L/6-1
	VA Per Phase	1667	3333	5000	10000	15000	30000
135/270 RANGE	LOAD RES	10.9	5.46	3.64	1.82	1.21	0.607
"	CURRENT LIMIT:						
	PROGRAM VALUE	10	20	30	60	90	180
	SET VALUE	10.7	21.5	32	64.5	96.8	194
156/312 RANGE	LOAD RES	14.59	7.3	4.86	2.43	1.62	0.811
"	CURRENT LIMIT:						
	PROGRAM VALUE	7.4	15	22.4	44.9	67.3	154
	SET VALUE	8	16.1	24	48.3	72.4	165
67.5/135 RANGE	LOAD RES	2.73	1.36	0.91	0.455		
"	CURRENT LIMIT:						
	PROGRAM VALUE	20	41	61	121		
	SET VALUE	21.4	43.8	65.2	129.4		
200/400 RANGE	LOAD RES	24	12	8	4	2.66	1.33
	CURRENT LIMIT:						
	PROGRAM VALUE	6.6	13.3	20	40	60	120
	SET VALUE	7	14	21.4	42.8	64	129

SETUP LOAD VALUES

TABLE 4-1

	MODEL	2750L/1-3	2750L/1-1
	VA Per Phase	1000	3000
135/270 RANGE	LOAD RES	18.2	6.07
"	CURRENT LIMIT:		
	PROGRAM VALUE	6	18
	SET VALUE	6.4	19.3
156/312 RANGE	LOAD RES	24.3	8.1
"	CURRENT LIMIT:		
	PROGRAM VALUE	4.5	13.5
	SET VALUE	4.8	14.4
67.5/135 RANGE	LOAD RES	4.55	1.51
"	CURRENT LIMIT:		
	PROGRAM VALUE	12	36
	SET VALUE	12.8	38
200/400 RANGE	LOAD RES	40	13.3
	CURRENT LIMIT:		
	PROGRAM VALUE	4	12
	SET VALUE	4.3	13

SETUP LOAD VALUES

TABLE 4-1 (continued)

4.3 PERIODIC CALIBRATION

The following periodic calibration adjustments should be performed on a 1 year interval.

4.3.1 VOLTAGE CALIBRATION

Apply power top the AC Power System and allow at least fifteen minutes for temperature stabilization. Program the output to 60 Hz, 135 volts and perform the following steps:

1. Connect the AC voltmeter to the phase to be calibrated.

2. Depress the MNU key several times until the first menu screen is displayed as illustrated below.

```
 SNC = 01      *CLK = 02
*WVF = 03       RNG = 04
```

   *May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

```
CFG = 16      ALM = 17
FLM = 18      CLM = 19
```

5. Select the CAL screen with the key sequence: 12 ENT

6. Depress the A, B or C key for the output phase to be calibrated. Verify that the other phases are in the MON mode. The A, B, or C keys will switch the respective phase between the MON and PRG mode.l If the output voltage is greater than the programmed output, depress and hold the ↓ key until the correct output voltage has been reached. The ↑ key is used if the output is less than the programmed value.

7. Repeat step 6 for other outputs to be calibrated.

4.3.2 VOLTAGE MEASUREMENT CALIBRATION

For calibration of voltage measurement first perform the output voltage calibration and then perform the followings steps:

1. Remove the load from the AC Power System and program 60 Hz and 135.0 volts.

2. Depress the MNU key several times until the Menu screen is displayed as illustrated below:

```
 SNC = 01      *CLK = 02
*WVF = 03       RNG = 04
```

*May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT.

4. Depress the MNU key several times until the configuration menu screen is displayed.

```
CFG = 16    ALM = 17
FLM = 18    CLM = 19
```

5. Enter the key sequence 13 ENT to access the CAL VLT screen.

6. If all phases of the voltage measurement are to be calibrated to 135.0, enter the key sequence:

```
135 PRG ENT
```

After about 5 seconds, the volt measurement function will be calibrated for all three phases.

If only one phase is to be calibrated to 135.0 volts (ex., phase A) enter the key sequence:

```
135 A PRG ENT
```

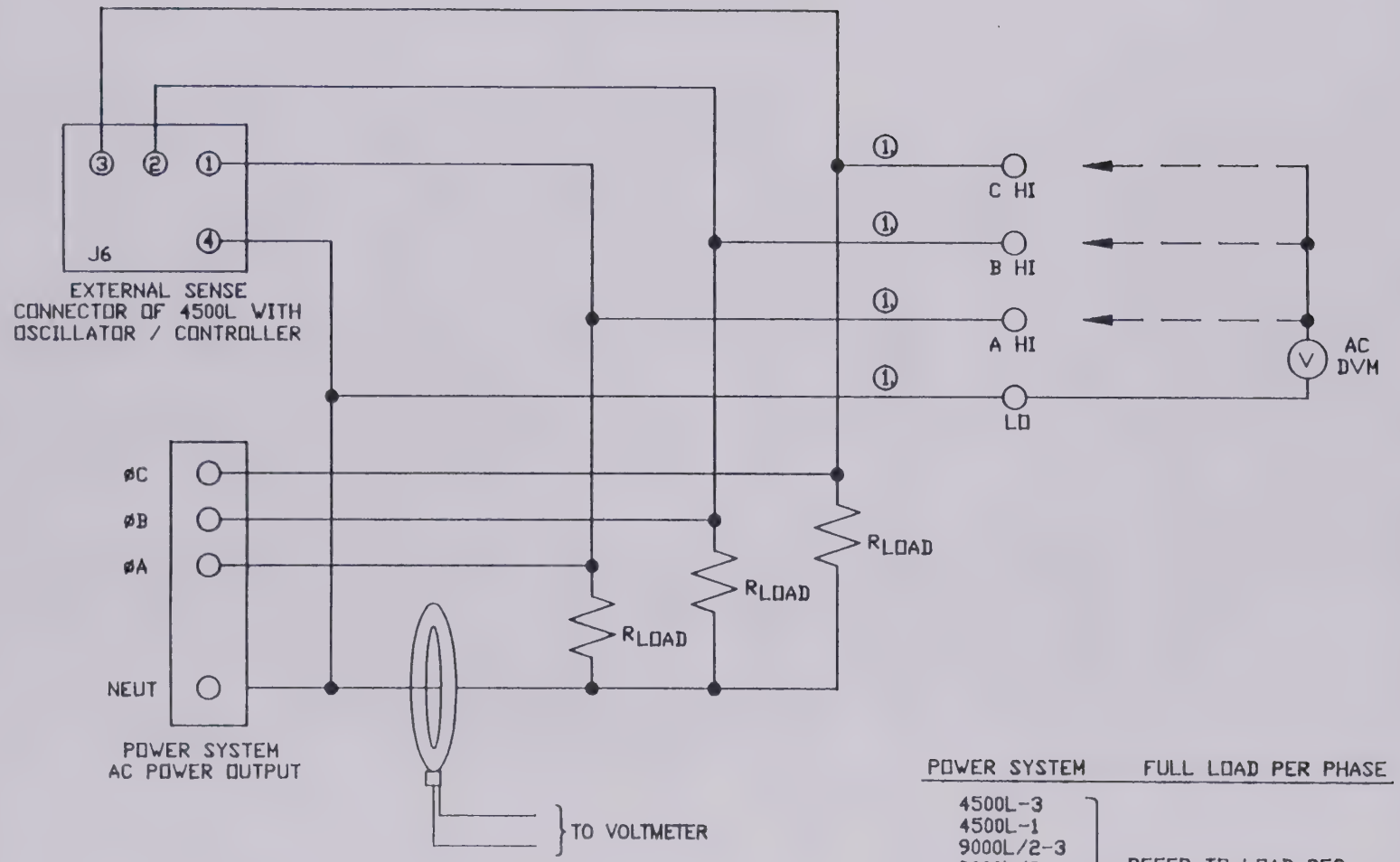


FIGURE 4-2

EQUIPMENT HOOKUP FOR PERIODIC CALIBRATION

4.3.3 CURRENT MEASUREMENT CALIBRATION

For calibration of current measurement perform the following steps:

1. Program 60 Hz, 135.0 volts and the maximum Current Limit value.

2. If any calibration screen is already displayed, the Current Calibration screen (CAL CUR) may be displayed by repeatedly depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, press the MNU key several times until the screen shown below is displayed:

```
 SNC = 01      *CLK = 02
*WVF = 03       RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed, as shown below:

```
CFG = 16      ALM = 17
FLM = 18      CLM = 19
```

5. Enter the key sequence: 14 ENT to access the CAL CUR screen.

   Determine the full load resistive value from the LOAD RES value from Table 4-1.

6. Apply the load to the phase A output only. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer.

7. On the keypad enter the key sequence:

   (Measured phase A current. Example 11.05) A PRG ENT

   After about 5 seconds the current measurement function for phase A will be calibrated.

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B current) B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

    (Measured phase C current) C PRG ENT

4.3.4 POWER MEASUREMENT CALIBRATION

For calibration of power measurement perform the following steps:

1. Program 60 Hz and 135.0 volts and the maximum Current Limit value.

2. If any calibration screen is already displayed, the Power Calibration screen (CAL PWR) may be displayed by depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, depress the MNU key several times until the screen shown below is displayed:

```
 SNC = 01      *CLK = 02
*WVF = 03       RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as shown below:

```
CFG = 16    ALM = 17
FLM = 18    CLM = 19
```

5. Enter the key sequence 15 ENT to access the CAL PWR screen.

6. Apply the LOAD RES value from Table 4-1 to the phase A output only. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer. Measure the phase A voltage from the phase A sense to neutral sense. Multiply the voltage and current values to determine the power value. (Note: The load must be resistive for the correct power value.)

7. On the keypad enter the key sequence:

   (Measured phase A power) A PRG ENT

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B phase) B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

(Measured phase C power) C PRG ENT

4.3.5 REMOTE MEASUREMENT CALIBRATION

The measurement function of the AC Power System may be remotely calibrated. The equipment hookup is the same as before except an IEEE-488 Controller must be used to program the AC Power System. The values for the VLT, CUR and PWR strings must be derived from the external AC Digital Voltmeters and Current Transformer.

To calibrate the measured voltage, first program the AC Power System to 135.0 volts and 60 Hz. Send the following calibration string:

CAL VLT (1) (Desired voltage value for phase (1))

To calibrate the measured current send the following string:

CAL CUR (1) (Desired current value for phase (1))

To calibrate the measured power value send the following string:

CAL PWR (1) (Desired power value for phase (1))

NOTE: (1) May be blank or include an A, B or C extension.

4.3.6 REMOTE OUTPUT VOLTAGE CALIBRATION

The ASCII # symbol can be used with a remote calibration to greatly reduce the calibration time. The ASCII # is used in place of a calibration coefficient to begin the CAL ramp to start at the existing CAL coefficient and ramp up or down for a VAL argument of 255 or 0 respectively.

The following string will cause the CAL coefficient to ramp down with a delay of .2 seconds per step:

CAL # DLY.2 VAL0

Figure 4-3 is a Flow Diagram for the Remote Calibration program that follows. The program was written in HP Basic for an HP Series 80 computer.

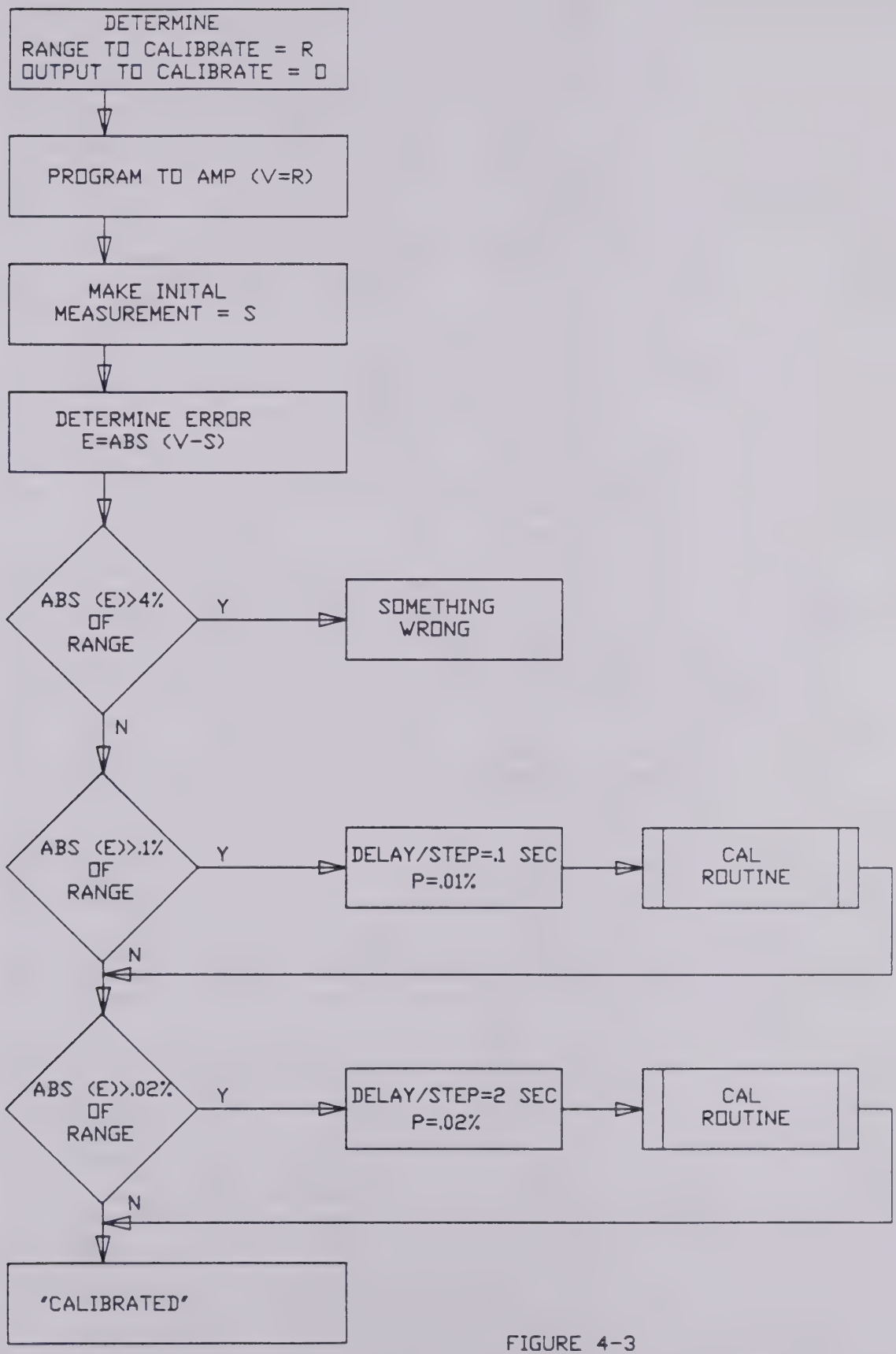


FIGURE 4-3
REMOTE CALIBRATION FLOW DIAGRAM

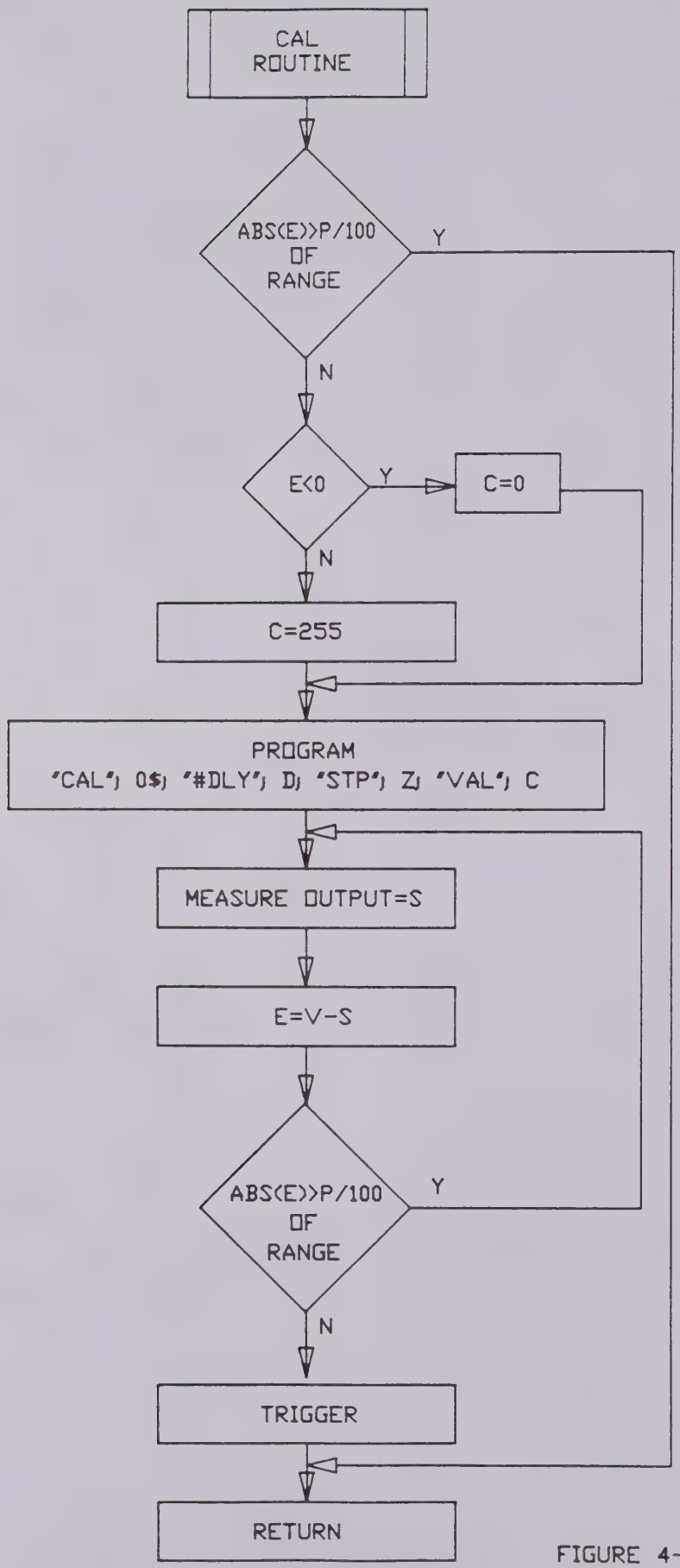


FIGURE 4-3 (CONTINUED)

```
10  ! CAL
20  SET TIMEOUT 7;5000 ! SET BUS TIMEOUT TO 5SEC
30  ! CLEAR 7! SEND DEVICE CLEAR
40  CLEAR
50  ABORTIO 7
60  R=135
70  O$="A"
80  DISP "THE AC POWER SYSTEM ADDRESS MUST BE 1 AND "
90  DISP "THE 8506A AC DVM ADDRESS MUST BE 4."
100 DISP "PRESS K1 TO CONTINUE"
110 ON KEY# 1 GOTO 140
120 GOTO 120
130 OFF KEY#
140 DISP "WHAT VOLTAGE RANGE TO CAL 135 OR 270.DEFAULT IS ";R
150 INPUT C$
160 IF C$ <> "" THEN R=VAL (C$)
170 CLEAR
180 IF R=135 THEN DISP "WHAT CAL. VOLTAGE FROM 60 TO 135? THE
    DEFAULT IS 135"
190 IF R=270 THEN DISP "WHAT CAL. VOLTAGE FROM 120 TO 270? THE
    DEFAULT IS 270."
200 INPUT V$
210 IF V$ <> "" THEN V=VAL (V$) ELSE V=R
212 ON TIMEOUT 7 GOTO 2000
214 IF V>125 THEN OUTPUT 704 ;"VAR7,"
216 IF V>40 AND V<= 125 THEN OUTPUT 704 ;"VAR6,"
218 IF V<= 40 THEN OUTPUT 704 ;"VAR5,"
220 DISP "WHICH OUTPUT TO CAL(DEFAULT IS ";O$;")"
230 INPUT P$
240 IF P$ <> "" THEN O$=P$
250 CLEAR
260 DISP "CONNECT THE 8506A AC DVM TO OUTPUT ";O$;"."
270 DISP "PRESS K1 TO CAL."
280 ON KEY# 1 GOTO 300
290 GOTO 290
300 OFF KEY#
310 GOSUB 1000
320 ! OUTPUT CALIBRATED TO WITHIN .02%
330 DISP "OUTPUT ";O$;" CALIBRATED. CAL ANOTHER OUTPUT(Y/N)"
340 INPUT A$
350 IF POS (A$,"Y")=1 THEN GOTO 220
360 LOCAL 7
370 END
500 ! CAL SUBROUTINE
510 ! DETERMINE IF OUTPUT IS WITHIN P% OF R
512 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
515 GOSUB 800
520 IF ABS (E)<P/100*R THEN GOTO 600
530 ! DETERMINE DIRECTION OF CAL COEFF. RAMP
540 IF E<0 THEN C=0 ELSE C=255
545 ON TIMEOUT 7 GOTO 3000
550 OUTPUT 701 ; "CAL AMP";O$;"#DLY";D;"STP";Z;"VAL";C
560 X=255
562 GOSUB 800
564 IF ABS (E)>ABS (X)+.005 THEN GOTO 590
```

```
566 IF ABS (E)<P/100*R THEN GOTO 590
568 WAIT D*1000
570 X=E
580 GOTO 562
590 TRIGGER 701 ! STOP CAL RAMP WITH DEVICE TRIGGER
600 RETURN
800 ! MEASURE ROUTINE
810 OUTPUT 704 ; "?"
820 ENTER 704 ; 6
830 E=V-S
840 RETURN
1000 ! GEN CAL
1010 ! PROGRAM TO SELECTED RANGE AND AMPLITUDE
1020 OUTPUT 701 ;"FRQ400RNG";R;"AMP";V
1030 WAIT 2000
1040 ON TIMEOUT 7 GOTO 2000
1042 WAIT 2000
1050 GOSUB 800
1070 UF ABS (E)>,04*R THEN GOTO 3000 ! NOT AT EXPECTED OUTPUT
1080 D=1 @ P=.1 @ Z=10 ! DLY=.1SEC FOR CAL TO APPROX. .1%
1090 GOSUB 500
1100 D=1 @ P=.02 @ Z=1 ! DLY=1SEC FOR CAL TO .02%
1110 GOSUB 500
1120 RETURN
2000 DISP "DVM IS INACTIVE. INSURE ADDRESS IS 4."
2010 GOTO 360
3000 DISP "CHECK THAT THE ADDRESS IS 1."
3010 DISP "THE MEASURED OUTPUT IS ",S
3020 GOTO 360
```

4.4 NONPERIODIC CALIBRATION

If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power System will have to be removed. A nonperiodic calibration will only be required if a related assembly is repaired or if the performance is out of specification.

4.4.1 OUTPUT FREQUENCY CALIBRATION

Connect the Frequency Counter to the phase A output. Program the output to 135.0 volts and 400.0 Hz. Engage the low-pass filter on the Frequency Counter to obtain the output frequency.

If the Frequency Counter does not indicate 400.000 ±0.004 Hz, adjust C43 for the correct frequency. Refer to Figure 4-1.

4.4.2 GAIN BALANCE ADJUSTMENT

CAUTION

> The Gain Balance Adjustment should not be made unless an amplifier assembly has been repaired. Each amplifier has been adjusted at the factory for an exact full scale output voltage (135, 67.5, 156 or 200 volts for standard, LV, HV or EHV voltage ranges) with a 5.000 VRMS amplifier input voltage. The amplifier input voltage may be checked at TP4, TP5 and TP6 on the Current Limit Board for Phase A, B and C amplifiers respectively. TP1 is the reference test point.

The following adjustment is for all power system models except the 2750L-3P and 4500L-3P. The 2750L-3P and 4500L-3P do not require a gain balance adjustment. Before performing the adjustment, the top cover of each power source must be removed. Remove the Current Limit Board and temporarily remove jumper W2, if it is installed.

If the output of any power source is connected to the output of any other power source (ex. 9000L/2-1, 9000L/2-3, 13500L/3-1, 27000L/6-3, 27000L/6-1) remove the connection.

The External Sense input to the master power source must remain connected. Refer to Figure 2-2 and 2-3 for the proper External Sense connections.

The following steps will verify that the amplifiers to be paralleled have been adjusted to the same gains. In order to perform this, the AC DVM input LO will be connected to the first amplifier output of a given phase. This output is referred to as ALO, BLO or CLO for the respective phase A, B or C output. The AC DVM HI will be connected to each amplifier's output. The amplifiers output is referred to as AHI, BHI or CHI on the AMPLIFIER GAIN BALANCE table.

1. Use the AMPLIFIER GAIN BALANCE table to check all of the amplifiers for the system being tested.

   For the output from each amplifier of a given phase, the AC DVM should display less that 0.25 VAC while the DVM is on the 200 VAC range.

2. If any measurement from the GAIN BALANCE check is out of specification, the gain of the amplifier with the AC DVM input LO test lead connected must first be checked.

   To check the gain of the amplifier, connect the AC DVM between the Output Neutral and Output High of the corresponding output. Connect an additional AC DVM HI input test point of the Current Limit Board indicated below. Connect the LO input to TP1.

OUTPUT	TEST POINT	ADJUSTMENT
A	TP4	R105 PHASE A AMP
B	TP5	R105 PHASE B AMP
C	TP6	R105 PHASE C AMP

3. Program the output to 135.0 or the maximum voltage allowed on the corresponding Voltage Range.

4. With exactly 135.0 volts, or the maximum voltage allowed on the range, the Current Limit test point must be 5.000 ±1mV.

5. Adjust R105 so that the voltage at the test point is 5.000 volts or = Vout(5/Vmax) if Vmax is not 135 volts.

6. Repeat step 1) and adjust R105 of the amplifier for the respective output so that the output balance voltage is at a minimum.

7. Remove the input power and reinstall jumper W2 on the Current Limit Board in all power sources.

8. Reconnect the outputs as shown in Figures 2-2 and 2-3.

SYSTEM	MASTER			SLAVE #1			SLAVE #2		
	A	B	C	A	B	C	A	B	C
2750L-1, 4500L-1	ALO	AHI	AHI						
9000L/2-1	ALO	AHI	AHI	AHI	AHI	AHI			
9000L/2-3	ALO	BLO	CLO	AHI	BHI	CHI			
13500L/3-1, 27000L/6-1	ALO	AHI	AHI	AHI	AHI	AHI	AHI	AHI	AHI
	[Additional slaves same as Slave #1]								
9000L/2-2	ALO	AHI	AHI	AHI	AHI	AHI	AHI	AHI	AHI
13500L/3-3	Additional A Slaves same as Master except A output measured as AHI								
27000L/6-3	Additional B Slaves same as Master except A output measured as BHI								
	Additional C Slaves same as Master except A output measured as CHI								

AMPLIFIER GAIN BALANCE TABLE

4.4.3 CURRENT TRANSFORMER ADJUSTMENT

The following adjustments must be made with jumper W2, on the Current Limit Assembly, removed. If the output of any power source is connected to the output of any other power source (ex. 9000L/2-1, 9000L/2-3, 13500L/3-1, 27000L/6-3, 27000L/6-1), remove the connection.

The External Sense input to the Master power source must remain connected.

For the following adjustments a load resistor must be connected to each output of every power source in the system. The load resistor must be capable of loading an amplifier to approximately 9 amps (4 amps for the 2750L). Only one amplifier at a time needs to be loaded.

1. Monitor the phase A output current with the Current Transformer and AC DVM. Measure the phase A voltage between TP10 and TP1 on the Current Limit Assembly.

2. Turn on the AC input to the AC Power System. Program 60 Hz and an output voltage that generates an output circuit of approximately 9 amps (4 amps for the 2750L).

3. Apply the resistive load to the output. Adjust R4 on the Range Relay assembly for the correct voltage at TP10 for the load current: (1 volt = 10 Amps). Remove the load before loading the next output to be calibrated.

4. Repeat steps 1 through 3 for A, B and C outputs of all 4500Ls. Refer to the following table for the adjustments and test points.

CURRENT TRANSFORMER ADJUSTMENTS

OUTPUT	ADJUSTMENT (Range Relay Assy)	TEST POINTS (TP1 is Gnd.) (Current Limit Assy)
A	R4	TP10
B	R10	TP2
C	R16	TP3

5. Reinstall jumper W2 on all Current Limit Assemblies if it has been removed. Reconnect all outputs as shown in Figures 2-2 and 2-3.

4.4.4 LOAD BALANCE ADJUSTMENT

CAUTION

The Load Balance Adjustment should not be made unless an amplifier assembly has been repaired. Each amplifier has been adjusted at the factory for an output regulation of -1.48% with a 1500 watt load.

The following adjustment procedure is for all power systems except the 2750L-3P and the 4500L-3P. The power system must be connected as shown in Figure 2-2. A load resistor, see LOAD RES in Table 4-1, must be connected to the phase A, B or C output of the power system.

For the following adjustments, two external AC DVMs must be used. The DVMs must be connected to test points on the Current Limit Board, A9. The input LO for the DVM is TP1 of the respective Current Limit Board. For all test points and adjustments, refer to Table 4-2 for the respective power system.

1. Program the output to the low voltage range and the output voltage to 80% of range. Program the frequency to 200 Hz and the maximum Current Limit. Apply the LOAD RES identified in Table 4-1 for the respective power system. Check that voltages listed in Table 4-2. Check that the voltage at the respective test points are within ±0.1 volts of the reference test point.

2. Program the output to the maximum voltage and recheck the Table 4-2 test points. If they differ by more than ±0.2 volts from the reference, readjust the adjustments at this full load current.

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: (±0.1V)
2750L-1 4500L-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as TP10
	"	"	TP3	R1 AMP C	"
9000L/2-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	"
	"	SLAVE	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	"
	"	"	TP3	R1 AMP C	"
9000L/2-3, and 18000/4-3	A	MASTER	TP10	None	Monitor voltage for reference
	"	SLAVES	TP10	R1 AMP A	Same voltage as MASTER TP10
	B	MASTER	TP2	None	Monitor voltage for reference
	"	SLAVES	TP2	R1 AMP B	Same voltage as MASTER TP2
	C	MASTER	TP3	None	Monitor voltage for reference
	"	SLAVES	TP3	R1 AMP C	Same voltage as MASTER TP3

TABLE 4-2

AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: (±0.1V)
13500L/3-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #1	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #2	TP10	R1 AMP A	Same voltage as MASTER TP10
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
13500L/3-3	A	MASTER	TP10	None	Monitor voltage for reference
9000L/2-2	"	"	TP2	R1 AMP B	Same as MASTER TP10
	"	"	TP3	R1 AMP C	" "
Not for 9000L/2-2	B	SLAVE #1B	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same as SLAVE 1B TP10
	"	"	TP3	R1 AMP C	" "
	C	SLAVE #1C	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same as SLAVE 1C TP10
	"	"	TP3	R1 AMP C	" "

TABLE 4-2 (continued)

AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: (±0.1V)
27000L/6-1	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #1	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #2	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #3	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #4	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #5	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "

TABLE 4-2 (continued)

AMPLIFIER GAIN BALANCE ADJUSTMENTS

SYSTEM	LOAD	SOURCE	TEST POINT (Current Limit Board)	ADJUSTMENT IF NEEDED	ADJUST FOR: (±0.1V)
27000L/6-3	A	MASTER	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as MASTER TP10
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #1A	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	B	SLAVE #1B	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as SLAVE #1B TP10
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #2B	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "
	C	SLAVE #1C	TP10	None	Monitor voltage for reference
	"	"	TP2	R1 AMP B	Same voltage as SLAVE #1C TP10
	"	"	TP3	R1 AMP C	" "
	"	SLAVE #2C	TP10	R1 AMP A	" "
	"	"	TP2	R1 AMP B	" "
	"	"	TP3	R1 AMP C	" "

TABLE 4-2 (continued)

AMPLIFIER GAIN BALANCE ADJUSTMENTS

4.4.5 CURRENT LIMIT CALIBRATION

1. Select the Current Limit (CRL) screen (Screen 8) and program the Current Limit PROGRAM VALUE from Table 4-1.

2. Monitor the power system phase A output current with the external current transformer and AC DVM. Connect an oscilloscope to the output.

3. Program the low voltage range and the voltage to 80% of range. Program the frequency to 60 Hz.

4. Apply the LOAD RES value from Table 4-1 to the power system phase A output only.

5. Increase the output amplitude slowly until the external AC current transformer indicates SET VALUE from Table 4-1. Slowly turn A9-R17 on the Current Limit Assembly in a counterclockwise direction until the output OVERLOAD indicator starts to illuminate.

6. Slowly readjust R17 in a clockwise direction just to a point that the OVERLOAD extinguishes. Repeat this step for all ADJUSTMENTS listed in Table 4-3 for phase A.

7. Remove the load for phase A and repeat steps 2) through 6) for phase B and C. Adjust the controls specified in Table 4-3 for phase B and C.

8. Program the CRL value to 5 amps and full voltage. Verify the output faults when any phase has the LOAD RES load value.

SYSTEM	PHASE LOADED	ADJUSTMENT	POWER SOURCE
4500L-3, 2750L-3	A	R17	MASTER
	B	R46	"
	C	R72	"
4500L-1,	A	R17	MASTER & SLAVES
9000L/2-1,13500L/3-1,	A	R46	" "
27000L/6-1	A	R72	" "
9000L/2-3	A	R17	MASTER & SLAVES
	B	R46	" "
	C	R72	" "
13500L/3-3,	A	R17	MASTER
27000L/6-3	A	R46	MASTER
9000L/2-2	A	R72	MASTER
	B	R17	ALL SLAVES FOR øB
	B	R46	" "
	B	R72	" "
	C	R17	ALL SLAVES FOR øC
	C	R46	" "
	C	R72	" "

TABLE 4-3

CURRENT LIMIT ADJUSTMENT

4.4.6 OUTPUT PHASE ANGLE CALIBRATION

The phase calibration values for phases B and C are entered on the Phase Offset (POF) screen.

To calibrate the output phase angle, connect either a Phase Meter or an oscilloscope between the phase to be calibrated and the phase A output. Program the phase B or C value to be calibrated from the Phase screen (PHZ). If an oscilloscope is used the calibration is best performed with a programmed angle of 0 degrees.

To calibrate the output phase angle, program 120.0 volts and 60 Hz.

To access the POF screen perform the following key sequences:

1. Access the Phase screen (PHZ).

2. Depress the MNU key several times until the following screen is displayed:

```
SNC = 01        CLK = 02
WFV = 03        RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the Configuration menu screen is displayed:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

5. To display the POF screen enter the key sequence: 20 ENT

If an oscilloscope is used and the respective phase is programmed to 0 degrees and 200 Hz, a 3 degree error is represented by 41 microseconds of the 0 volt point of the two signals.

The POF values may be either a positive or negative value. A negative value is entered by depressing the period key (.) two times after the numerical value is entered before the PRG key is depressed.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

An explanation of the circuits within the AC Power System is given in this section. Refer to Figure 5-1 for a block diagram of the AC Power System.

5.2 OVERALL DESCRIPTION

Input power from the rear panel is routed through the circuit breaker to the Input Power Supply (A5). DC voltages from the Input Power Supply are routed to the Power Mother Board (A4), the Control Mother Board (A8) and the Auxiliary Power Supply (A7).

The Programmable Oscillator assembly (A11) generates the oscillator waveforms and power source control and measurement signals. The oscillator assembly is connected to the rest of the power source through the Control Mother Board, A10.

The three amplifier modules are A1, A2 and A3. They take their DC supply voltages and input signal from the Power Mother Board, A4. They produce the high power outputs for the primary of the output transformers, T1, T2 and T3. The outputs are routed through the Power Mother Board to the output transformers.

The Range Relay Board is identified as A6. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The outputs from the AC Power System are taken from the Range Relay Board. This board also has relays that switches the output to the 1-phase mode and opens the outputs. There is also a circuit on the board that senses for incorrect sense line connections.

The board assemblies are described in more detail in the following paragraphs.

5.3 INPUT POWER SUPPLY

This assembly is identified as A5. It generates the high power +300 VDC supply. This supply voltage is connected to the filter capacitor, C1, and to the Power Mother Board. C1 is mounted on the bottom cover of the AC Power System.

The Input Power Supply also has circuits that generate the DC voltages identified as ±18V, ±15VSW, +8VSW and +8V.

The ±18V supplies are used for the Oscillator Module and the Current Limit Board. The +8V supply is used for the Oscillator Module. The ±15VSW supplies are used for the three Amplifier Modules.

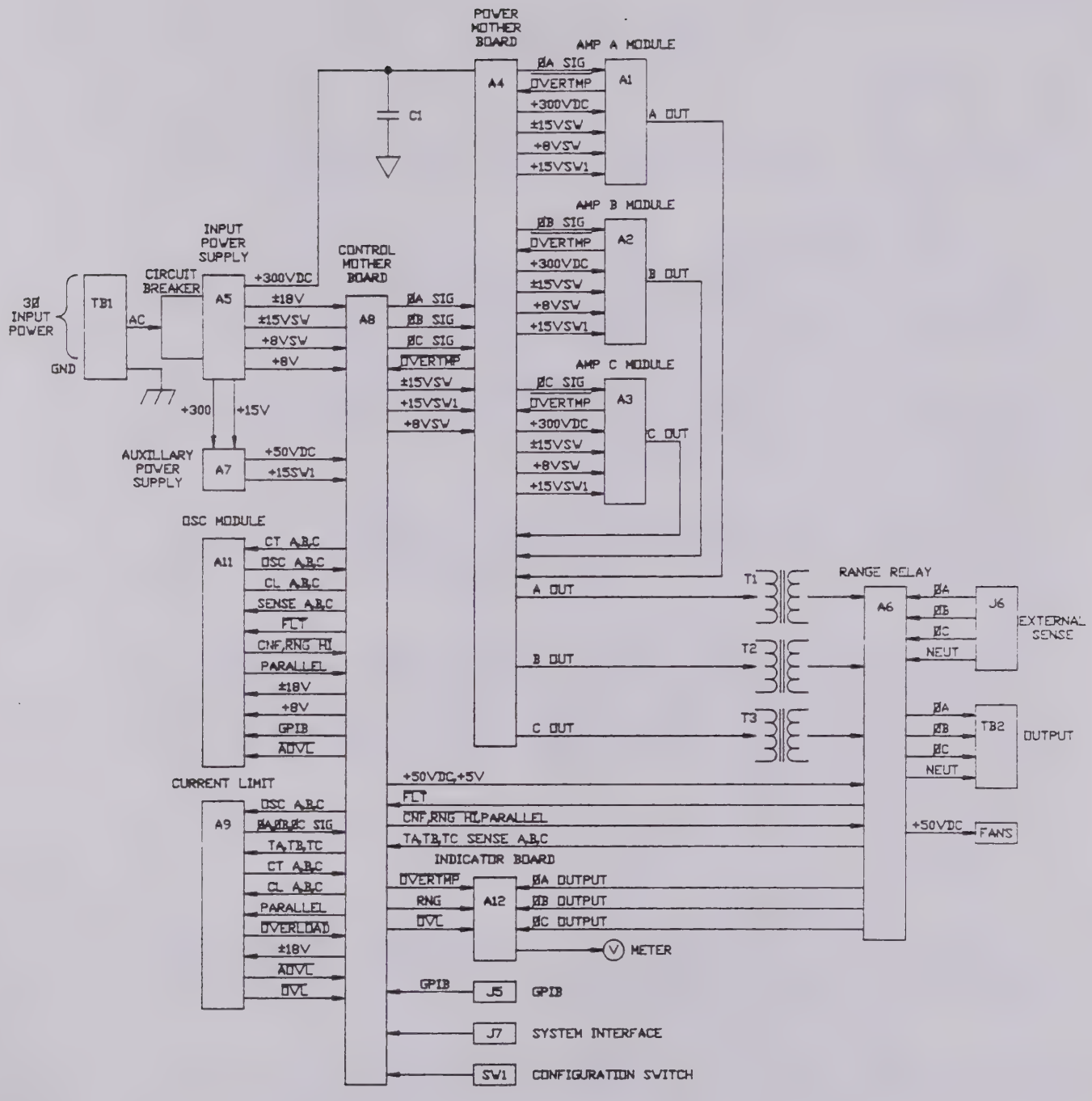


FIGURE 5-1
AC POWER SYSTEM BLOCK DIAGRAM

5.4 AUXILIARY POWER SUPPLY

The Auxiliary Power Supply receives the +300 supply voltage from the Input Power Supply. The +300 supply voltage is then changed to the +50 VDC supply voltage for operating the fans and relays. In addition to the +50 VDC supply, +15VSW1 is also generated. This supply voltage is used for the gate drive signal in the Amplifier Modules.

5.5 CURRENT LIMIT BOARD

The Current Limit Board receives the oscillator signals identified as OSC A, B and C from the Oscillator Module. Analog switches on this board direct the oscillator signals to the respective amplifier module. The analog switches switch the OSC A signal to the three amplifier inputs during 1-phase operation. For 3-phase operation, OSC A, B and C are switched to the amplifiers A, B and C inputs respectively. Gain adjustments are located on this board to match the gains of the 3 Amplifier Modules.

The current limit circuits are also located on the Current Limit Board. These circuits receive a DC signal from the Oscillator Module, CLA, B and C, that is proportional to the current limit value. This DC signal is compared to the output current. The output current signal is identified as TA, TB and TC. This signal is routed to the Current Limit Board from current transformers on the Range Relay Board. If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power System to operate at a constant current. If the output current limits the output voltage to 10% of the programmed voltage amplitude value, the output will default and an AMP FAULT error message will be displayed. The error message will also be reported through the IEEE-488 (GPIB) interface.

The Current Limit Board has analog switches and summing amplifiers that are used for current measurements. The outputs from the summing amplifiers, CT A, B and C, are routed to the Oscillator Module for measurement. In the 1-phase mode the current from all three output current transformers are summed together for measurement. This signal is identified as CT A.

5.6 INDICATOR BOARD

The Indicator Board has the reference designator, A12. This board has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

A front panel selector switch is mounted on the Indicator Board. This switch is used to connect the front panel analog meter, M1, to either the phase A, B or C output.

5.7 RANGE RELAY BOARD

The Range Relay Board has all of the AC Power System relays. These Relays are operated from +50 VDC. The output relay is opened by a logic low on the CNF control line. The range relay is switched to the high voltage range by a logic low on the $\overline{\text{RNG HI}}$ control line. The output is in the 1-phase mode when the PARALLEL control line is driven to approximately +10 VDC.

There are three current transformers on the Range Relay board. These transformers generate an AC voltage that is proportional to the output current. The voltages are identified as TA, TB and TC. A 10 amp load current is represented by a 1.00 VAC signal in the 3-phase mode.

5.8 AMPLIFIER MODULES

The AC Power System has three Amplifier Modules. In the 3- phase mode, one amplifier is used for each of the three outputs. In the 1-phase mode, the three outputs are paralleled at the secondaries of the output transformers.

The Amplifier Modules operate in a switch mode to obtain high efficiency. These switch mode amplifiers operate at 200 KHz.

Each Amplifier Module obtains its input signal from the Current Limit Board. These three input signals are identified as ϕA SIG, ϕB SIG and ϕC SIG. A 5.00 VRMS input signal will generate a full scale output voltage at the output of the AC Power System and 100.0 VRMS on the primary of the output transformer.

Each Amplifier Module requires +300 DC, $\pm$15 VSW, and the +15 VSW1 supplies. The +300 VDC supply comes from the Input Power Supply through a 15 amp fuse on the Power Mother Board.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100°C, a control signal is sent to the Oscillator Module. A logic low on the $\overline{\text{OVER TMP}}$ control line will cause the error message TEMP FAULT to be generated.

5.9 OSCILLATOR MODULE

The Oscillator Module is identified with the reference designator, A11. The module consists of three printed circuit assemblies. These three assemblies are interconnected with a small mother board, A11A2. The oscillator Display Assembly connects to the Oscillator Module with a short ribbon cable. The Display Assembly is mounted on the front panel. The block diagram of the Oscillator Module is shown in Figure 5-2.

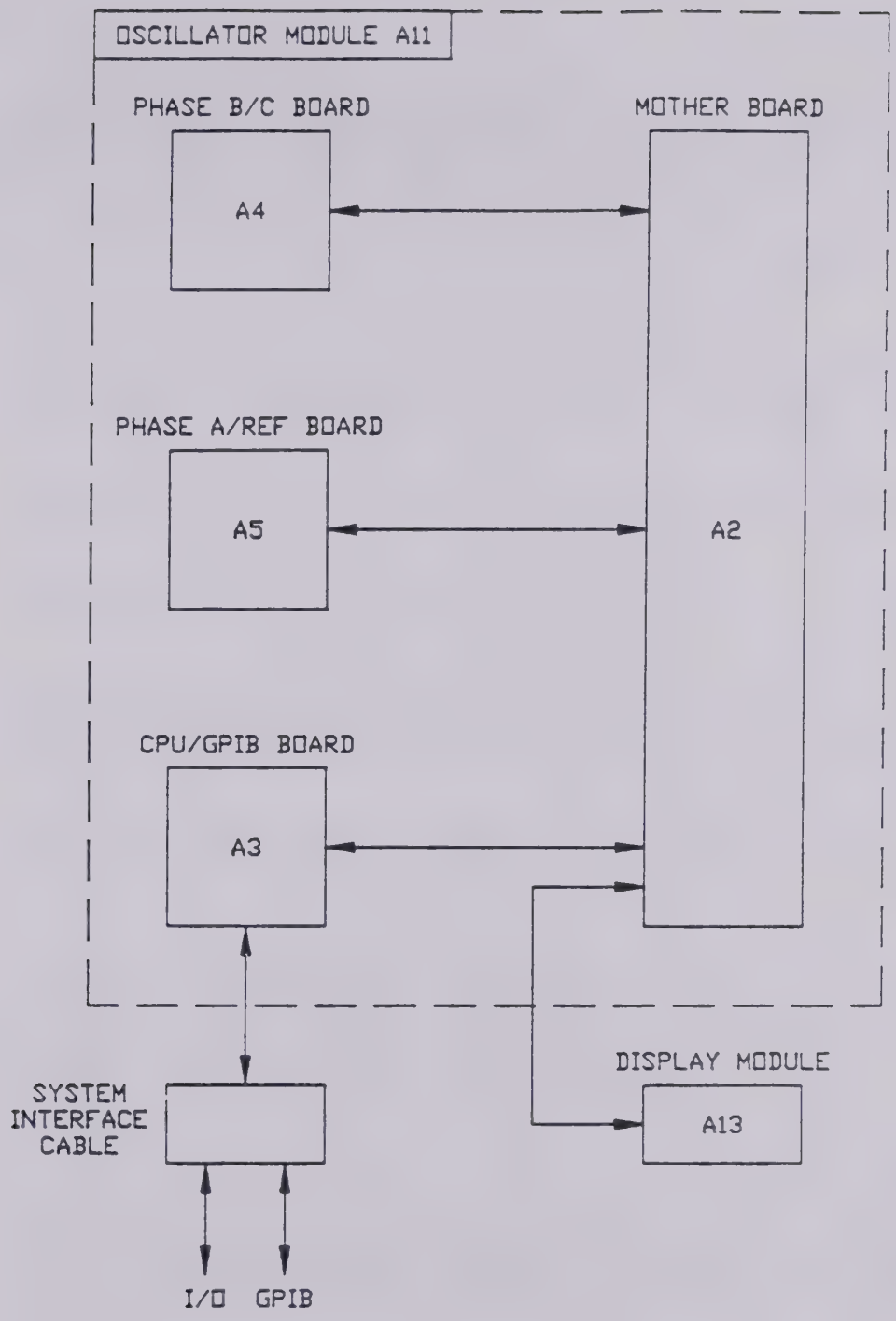


FIGURE 5-2
PROGRAMMABLE OSCILLATOR MODULE

5.10 CPU/GPIB BOARD

The CPU/GPIB board, A11A3, provides the control and measurement functions of the module. A microprocessor circuit accepts commands from the GPIB on the front panel keyboard. It sends digital programming information to set the output parameters of the power source. Data from measurement circuits are accepted and reported to the display and GPIB. Measurement calibration coefficients are stored in a memory backed up by a battery. The battery has a 10 year life expectancy.

Measurement circuits on the CPU/GPIB board monitor voltage, current, power, frequency, and phase angle. Voltage from the rear panel sense connector is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

Current sensed by internal current transformers is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

The scaled voltage and current waveforms are applied to the inputs of a multiplier. The multiplier output is filtered to a DC level and digitized by the analog-to-digital converter.

Frequency is computed from the measured time intervals between zero crossings of the Phase A waveform. Phase is computed from the differences of measured zero crossings between the Phase A signal and the Phase B or Phase C signal.

A digital-to-analog converter on the CPU/GPIB board sets the DC voltages that are used for the programmable current limit function.

5.11 PHASE A/REF BOARD

The Phase A/Ref Board, A11A5, serves several purposes. A programmable clock sets the output frequency of the power source. Digital-to-analog converters program references to set the output amplitude of Phases A, B and C. A sine wave generator creates a 1024 step waveform which is filtered to provide the Phase A oscillator signal. A external sense amplifier controls the Phase A output amplitude.

5.12 PHASE B/C BOARD

The Phase B/C Board, A11A4, uses the DC voltage references and programmable clock from the Phase A/Ref board to generate the Phase B and C oscillator waveforms. External sense circuits control the Phase B and C output amplitudes.

5.13 DISPLAY MODULE

The Display Board, A11A13, is held to the power source by a small panel and is connected through a short ribbon cable. It holds the 20 button keyboard and a 32 character LCD display. A knob on the board allows the display viewing angle to be adjusted.

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power System does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

TABLE 6-1

PARAGRAPH	PROBLEM	PAGE
6-2	Poor Voltage Accuracy	133
6-3	Poor Output Voltage Regulation	133
6-4	Overtemperature Lamp On	134
6-5	Overload Lamp On	134
6-6	Can't Program AC Power System on GPIB	135
6-7	Distorted Output	135
6-8	No Output	135

6.2 POOR VOLTAGE ACCURACY

If the power source exhibits poor programmed voltage accuracy, the following item may be at fault:

1. The calibration is incorrect.

   SOLUTION: Calibrate the output. Refer to Paragraph 4.3.1.

6.3 POOR OUTPUT VOLTAGE REGULATION

If the AC Power System exhibits poor voltage regulation the following item may be at fault:

1. The External Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation check.

   SOLUTION: Connect AC voltmeter to External Sense lines.

6.4 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following may be at fault:

1. Ambient temperature is too high.

   SOLUTION: Operate power source between 0 and 35° C.

2. Fan or ventilation holes are blocked.

   SOLUTION: Remove obstructions.

3. Fan not working.

   SOLUTION: Replace fan. Consult factory.

6.5 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the output load current has exceeded the programmed current limit value. For all power systems except the 2750L-3P and the 4500L-3P, mis-adjustment of either the Amplifier Gain or Load Balance will cause the OVERLOAD Lamp to illuminate. If the AC Power System OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

   SOLUTION: Remove the overload.

2. The programmable current limit level is set too low for the load being driven.

   SOLUTION: Compute and reprogram the correct programmable current limit level.

3. The programmable current limit is incorrectly calibrated.

   SOLUTION: Perform the calibration in paragraph 4.4.5.

4. The adjustment of the Amplifier Gain Balance or Load Balance is incorrect.

   SOLUTION: Perform the adjustments in paragraph 4.4.2 and 4.4.4.

5. Incorrect AC Power Source configuration. Check the ELT screen. It should show more than 24 hours of operation. If it shows less than 24 hours consult the factory.

6.6 CAN'T PROGRAM AC POWER SYSTEM ON GPIB

If the power source does not respond to IEEE-488 GPIB programming, the following items may be at fault:

1. The power source unit address is wrong.

   SOLUTION: Update address. See paragraph 3.7.1.

2. GPIB cable is loose at power source rear panel.

   SOLUTION: Check connection, tighten jack screws.

3. The oscillator has failed.

   SOLUTION: Replace the oscillator. See Paragraph 6.10.

6.7 DISTORTED OUTPUT

The AC Power System output may have a distorted sine wave from the following causes:

1. The power source output is overloaded.

   SOLUTION: Remove the overload or program the current limit to a higher value. Observe power source capabilities. See Section 1.

2. The crest factor of the load current exceeds 2.5. With this condition the distortion will be much higher at frequencies above 100 Hz.

   SOLUTION: Reduce the load or program the current limit to a higher value.

6.8 NO OUTPUT

If the AC Power System has no output at the rear panel terminal block, TB1, the following items may be at fault:

1. If the External Sense lines are not connected correctly, there will be no output. The error message AMP FAULT will also be generated.

   SOLUTION: Correctly connect the sense lines. Refer to Paragraph 2.5.

2. When the output is overloaded an error message will be generated and the output relays will open. The error message would be AMP FAULT.

SOLUTION: Remove the overload. Observe the output power capabilities. Refer to Section 1.

3. There is no input to the power amplifiers from the oscillator. Check the oscillator signals at the system interface connector:

   J7-24 Oscillator Phase A
   J7-6 Oscillator Phase B
   J7-23 Oscillator Phase C
   J7-7 Oscillator common/return

   Program 135.0 volts on the 135 volt range. The three signals should be 5.0 ±0.10 VAC.

   SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6.9.

   SOLUTION: If the signal at the System Interface connector is greater than 5.0 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6.11.

4. One of the internal fuses, F1, F2 or F3 has failed.

   SOLUTION: Replace the fuse. Remove the input power and discharge capacitor C1 before replacing the fuse. Refer to paragraph 6.11.

6.9 MODULE REMOVAL

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Modules, A1, A2 and A3, with the insulator removed.

6.10 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the Oscillator Module (assembly 4009-425) perform the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker.

2. Remove the power system's top cover.

3. Remove the Keyboard/Display assembly by loosening the two captive screws on its front panel.

4. Unplug the ribbon cable from the Keyboard/Display assembly.

5. Remove the Oscillator Module, A11, by pulling up the package of PC assemblies.

6. The module is now removed. To replace the module follow these steps in reverse order. Make sure the ribbon cable that plugs into the Keyboard/Display assembly runs between PC assembly, A12, and the front panel.

6.11 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that indicates the failure of an amplifier module (assembly 4009-423), check the condition of the +300 VDC fuses before replacing the amplifier. Refer to Figure 6-1 for the location of the fuses. Fuse F1 is for phase A, F2 for phase B and F3 is for phase C.

CAUTION

Capacitor C1 may have up to +350 VDC after the input circuit breaker has been turned off. Before inspecting fuses F1, F2 and F3, discharge C1. C1 may be discharged through a 5 ohm power resistor.

If it is determined that an amplifier module must be replaced perform the following procedure:

1. Turn off the input circuit breaker.

2. Remove the AC Power System top cover.

3. Remove the four #6 screws that hold the insulator that covers the amplifier module, A1, A2 and A3.

4. Remove any of the three amplifiers by sliding it up and over the guide posts.

5. The amplifier may be replaced by following this procedure in reverse order.

6. Check the amplifiers associated 10 amp and fuse and replace it if necessary. Refer to Figure 6-1 for the location of the fuse. F1, F2 and F3 are for the phase A, B and C amplifiers respectively.

7. After an amplifier has been replaced, readjust its gain and the 1-phase adjustment. Refer to Section 4.

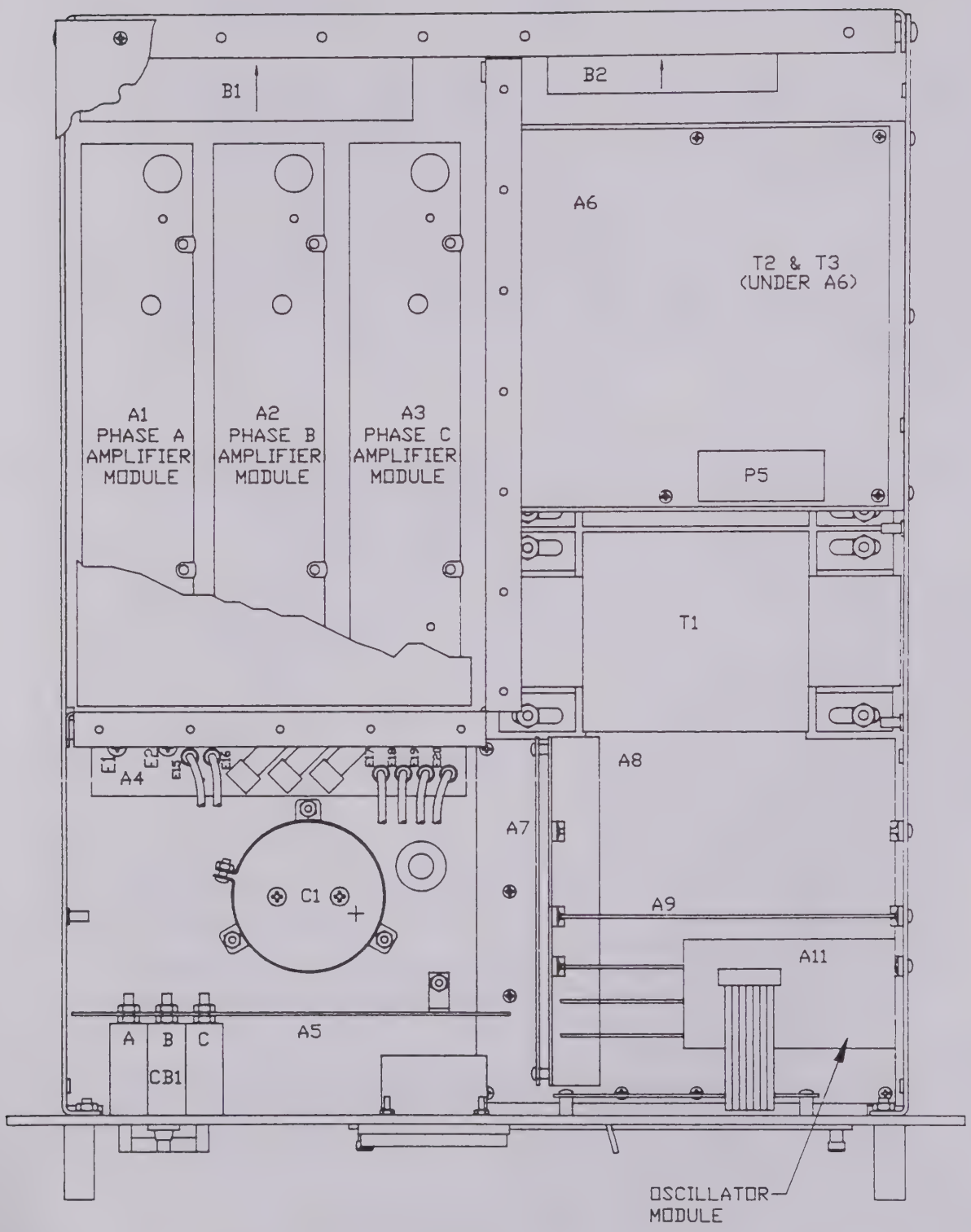


FIGURE 6-1
MODULE LOCATION

SECTION 7

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and a complete list of replaceable parts. The parts are listed by their major assembly in alpha-numeric order by their reference designators. The list includes the parts description, manufacturers' identification (see Appendix A for list of manufacturers), and California Instruments' part numbers.

7.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable, for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the subassembly where component is located (PARENT ITEM NO.).

c. Component reference designator (SEQ NO.).

d. Component description (DESCRIPTION TRUNCATED).

e. Component manufacturer's FSCM number (VENDOR).

f. California Instruments part number (COMPONENT ITEM NO.).

All replacement part orders should be addressed to:

California Instruments
Attention: Parts Department
9025 Balboa Avenue
San Diego, California 92123-1509

TOP ASSEMBLY REPLACEABLE PARTS
FOR 4500L-P and 2750L-P
TOP ASSEMBLY NO: 4009-422-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4009-423-1	HEATSING ASSY, SW AMP	16067	1.0
A2	4009-423-1	HEATSINK ASSY, SW AMP	16067	1.0
A3	4009-423-1	HEATSINK ASSY, SW AMP	16067	1.0
A4	4009-724-1	PC ASSY, MOTHER	16067	1.0
A5	4009-706-1	PC ASSY, POWER SUPPLY	16067	1.0
A6	4009-733-1	PC ASSY, RANGE	16067	1.0
A7	4009-735-1	PC ASSY, AUX POWER SUPPLY	16067	1.0
A8	4009-732-1	PC ASSY, MOTHER, CTRL	16067	1.0
A9	4009-728-1	PC ASSY, CURRENT LIMIT	16067	1.0
A11	4009-425-1	MODULE ASSY, OSC	16067	1.0
A12	4009-707-1	PC ASSY, INDICATOR	16067	1.0
B1	241178	FAN, 6", 48VDC, .45A	63227	1.0
B2	241175	FAN, 4", 48VDC,	23936	1.0
C1	611295	CAP, AL, 3900μF, 400V	80031	1.0
A4F1	270167	FUSE, 15A, 250V	71400	1.0
A4F2	270167	FUSE, 15A, 250V	71400	1.0
A4F3	270167	FUSE, 15A, 250V	71400	1.0

SECTION 8

MIL-STD-704D

8.1 GENERAL

The MIL-704D option is capable of performing all sections of MIL-STD-704D. It will perform all tests in the order listed below or part of the test. There is a 5 second delay between tests to allow the operator to evaluate the result of the test.

8.2 INITIAL SETUP

Nominal parameters for the AC Power Source shall be as follows:

OUTPUT VOLTAGE:	115 L-N
OUTPUT FREQUENCY:	400
OUTPUT PHASE ANGLE:	B 240 C 120

8.3 TEST PERFORMED

8.3.1 Steady state test. (Refer to MIL-704D Doc. Table 1)

1. Voltage per Figure 1, page 151
2. Voltage unbalance per Figure 2, page 151
3. Voltage phase difference per Figure 3, page 151
4. Waveform distortion factor per Figure 4, page 151
5. Frequency per Figure 5, page 151

8.3.2 Transient

1. Voltage Transient (Refer to MIL-704D Doc. Figure 5.)
   High voltage Transient per Figure 6, page 152
   Low voltage Transient per Figure 7, page 152

2. Frequency Transient (Refer to MIL-704D Doc. Figure 6)
   High frequency Transient per Figure 8, page 153
   Low frequency Transient per Figure 9, page 153

8.3.3 Abnormal operation

1. Abnormal voltage (Refer to MIL-704D Doc. Figure 7).
   Overvoltage per Figure 10, page 154
   Undervoltage per Figure 11, page 154

2. Abnormal frequency (Refer to MIL-704D Doc. Figure 8)
   Overfrequency per Figure 12, page 155
   Underfrequency per Figure 13, page 155

8.3.4 Emergency operation (Refer to MIL-704D Doc. 5.2.5)

1. Voltage per Figure 14, page 156
2. Frequency per Figure 15, page 156

8.4 KEYPAD ENTRY (Refer to page 149 for Keyboard flow chart)

To perform a test from the key board, the following key sequence is required:

704 ENT

The following screen will appear:

```
MIL704D:SelA,B,C
ENT=all CLR=EXIT
```

Pressing the A, B, C or any combination selects the phase in test. Press ENT without the phase select for simultaneous three-phase test.

The following screen appears for a short time.

```
TEST A,B,C
CLR to Reselect
```

The next screen is:

```
Apply Nom Output
Press ENT
```

When ENT is selected the following screen appears:

```
Press MNU to
Select Test
```

The MNU screen has two lines of selection shown at a time.

There are 3 different types of operations that can be selected from a MENU acreen. If the word MENU appears for the item selected, another MENU screen will be displayed. If the word TEST appears fir the item selected, the test will start. The display will return to the previous screen if the word RETURN appears for the item selected.

The Main Menu will appear as follows:

```
1=Steady St Menu
2=Transient Menu
3=Abnormal Menu
4=Emergency Menu
5=MIL704D Test
6=Return
```

If key 1 is selected "Steady State: from the Main Menu, the following Menu will appear:

```
1=Voltage Test
2=Unbalance Test
3=Phase dif Test
4=Wave dist Test
5=Frequency Test
6=Steady St Test
7=Return
```

If key 2 is selected "Transient" from the Main Menu, the following Menu will appear:

```
1=Volt Trns Menu
2=Freq Trns Menu
3=Transient Test
4=Return
```

If key 1 is selected from the Transient Menu the following Menu will appear:

```
1=High Volt Test
2=Low Volt Test
3=Volt Trns Test
4=Return
```

If key 2 is selected from the Transient Menu the following Menu will appear:

```
1=High Freq Test
2=Low Freq Test
3=Freq Trns Test
4=Return
```

If key 3 is selected "Abnormal" from the Main Menu, the following Menu will appear:

```
1=Abnl Volt Menu
2=Abnl Freq Menu
3=Abnormal Test
4=Return to Main Menu
```

If key 1 is selected from the "Abnormal" Menu, the following Menu will appear:

```
1=Overvolt Test
2=Undervolt Test
3=Abnl Volt Test
4=Return
```

If key 2 is selected from the "Abnormal" menu, the following Menu will appear:

```
1=Overfreq Test
2=Underfreq Test
3=Abnl Freq Test
4=Return
```

If key 4 is selected "Emergency" from the Main Menu, the following Menu will appear:

```
1=Emrg Volt Test
2=Emrg Freq Test
3=Emergency Test
4=Return
```

8.5 GPIB OPERATION (Refer to page 150 for syntax diagram)

The following command will be used to execute the appropriate part of all of the test.

```
MIL704D[A][B][C]                Test all MIL704D Sections
MIL704D[A][B][C] :STEady state
MIL704D[A][B][C] :STEady state :VOLTage
MIL704D[A][B][C] :STEady state :VOLTage :UNBalance
MIL704D[A][B][C] :STEady state :PHASe :DIFFerence
MIL704D[A][B][C] :STEady state :WAVeform :DISTortion
MIL704D :STEady state :FREQuency

MIL704D[A][B][C] :TRANsient
MIL704D[A][B][C] :TRANsient :VOLTage
MIL704D[A][B][C] :TRANsient :VOLTage :HIGH
MIL704D[A][B][C] :TRANsient :VOLTage :LOW
MIL704D :TRANsient :FREQuency
MIL704D :TRANsient :FREQuency:HIGH
MIL704D :TRANsient :FREQuency:LOW

MIL704D[A][B][C] :ABNormal
MIL704D[A][B][C] :ABNormal :VOLTage
MIL704D[A][B][C] :ABNormal :VOLTage :OVER
MIL704D[A][B][C] :ABNormal :VOLTage :UNDer
MIL704D :ABNormal :FREQuency
MIL704D :ABNormal :FREQuency :OVER
MIL704D :ABNormal :FREQuency :UNDer

MIL704D[A][B][C] :EMERgency
MIL704D[A][B][C] :EMERgency :VOLTage
MIL704D :EMERgency :FREQuency
```

All lower case letters are option. [A],[B],[C] represent phase A, B, C. They are optional if they are omitted; the test will be applied to all three phases.

8.6 TEST SPECIFICATION

8.6.1 STEADY STATE

1. Steady state voltage test (Figure 1).

   MIL704D[A][B][C] :STEady state :VOLTage

   This test will change the output voltage simultaneously from 115 volts to 108 volts for 5 seconds to 118 volts for 5 seconds. The unselected phases will remain at 115 volts.

2. Steady state voltage unbalance test (Figure 2).

   MIL704D[A][B][C] :STEady state :VOLTage :UNBalance

   This test will change the output for phase A from 115 volts to 112 volts for 5 seconds and to 118 volts for 5 seconds. The test will repeat itself for phase B and phase C if they are selected.

3. Steady state voltage phase difference test (Figure 3).

   MIL704D[A][B][C] :STEady state :PHASe :DIFFerence

   This test will change phase B program phase angle, if it is selected, from 240 degrees to 236 degrees for 5 seconds and to 244 degrees for another 5 seconds. The test will be repeated for phase C, if it is selected.

4. Steady state waveform distortion (Figure 4).

   MIL704D[A][B][C] :STEady state :WAVeform :DISTortion

   This test will generate a 5% distortion on the selected phase for 5 seconds.

5. Steady state frequency test (Figure 5).

   MIL704D :STEady state :FREQuency

   This test will change the programmed frequency from 400 Hz to 393 Hz for 5 seconds then to 407 Hz for 5 seconds.

6. Steady state test

MIL704D[A][B][C] :STEady state

This test will perform all the above five tests in the same order above. A 5 second pause between tests is asserted.

8.6.2. TRANSIENT

1. Transient high voltage test (Figure 6).

MIL704D[A][B][C] :TRANsient :VOLTage :HIGH

This test requires a 180 volts range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for range change and after 5 seconds the test will begin.

The output will go to 180 volts for 10 msec and will drop gradually to 115 volts in 81.25 msec. After 5 seconds, a range change will take place to the original setup. This is a simultaneous test to all selected phases.

2. Transient low voltage test (Figure 7).

MIL704D[A][B][C] :TRANsient :VOLTage :LOW

The output voltage will drop to 80 volts for 10 msec. It will gradually rise to 115 volts in 81.25 msec. This test is a simultaneous test to all selected phases.

3. Transient voltage test

MIL704D[A][B][C] :TRANsient :VOLTage

This test will combine High voltage transient and Low voltage transient. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts, the High voltage transient test will not take place.

4. Transient high frequency test (Figure 8).

MIL704D :TRANsient :FREQuency:HIGH

This test will step up the frequency from 400 Hz to 425 Hz. The frequency will step down to 400 Hz in the following sequence:

425 Hz for 1 second
420 Hz for 4 seconds
410 Hz for 5 seconds
407 Hz for 4 seconds

5. Transient low frequency test (Figure 9).

MIL704D :TRANsient :FREQuency:LOW

This test will step down the frequency from 400 Hz to 375 Hz. The frequency will step up to 400 Hz in the following sequence:

375 Hz for 1 second
380 Hz for 4 seconds
390 Hz for 5 seconds
393 Hz for 4 seconds

6. Transient frequency test

MIL704D :TRANsient :FREQuency

This test will combine the high frequency transient and the low frequency transient. There is a pause of 5 seconds between tests.

8.6.3. ABNORMAL

1. Abnormal overvoltage test (Figure 10).

MIL704D[A][B][C] :ABNormal :VOLTage :OVER

This test requires a 180 volt range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for the range change and after 5 seconds the test will begin.

The output will go to 180 volts for 50 msec and will drop gradually to 125 volts in 450 msec. The output voltage will remain at 125 volts for 9.5 seconds before it drops to 115 volts. After 5 seconds, a range change will take place to the original setup. This is a simultaneous test to all selected phases.

2. Abnormal undervoltage test (Figure 11).

MIL704D[A][B][C] :ABNormal :VOLTage :UNDer

The output voltage will drop to 0 volts for 7 seconds. It step up to 100 volts for 3 seconds before it will go to 115 volts. This is a simultaneous test for all selected phases.

3. Abnormal voltage test

MIL704D[A][B][C] :ABNormal :VOLTage

This test will combine Abnormal overvoltage and Abnormal undervoltage. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts the Abnormal overvoltage test will not take place.

4. Abnormal overfrequency test (Figure 12)

MIL704D :ABNormal :FREQuency :OVER

This test will step up the frequency from 400 Hz to 480 Hz. The frequency will step down to 400 Hz in the following sequence:

480 Hz for 5 seconds
425 Hz for 5 seconds

5. Abnormal underfrequency test (Figure 13)

MIL704D :ABNormal :FREQuency :UNDer

This test will step down the frequency from 400 Hz to 0 Hz. The frequency will step up to 400 Hz in the following sequence:

0 Hz for 5 seconds
375 Hz for 5 seconds

6. Abnormal frequency test

MIL704D :ABNormal :FREQuency

This test will combine the Abnormal overfrequency and the Abnormal underfrequency . There is a pause for 5 seconds between tests.

8.6.4. EMERGENCY

1. Emergency voltage test (Figure 14).

MIL704D[A][B][C] :EMERgency :VOLTage

This test will step down the voltage to 104 volts for 5 seconds. Also it will step up the voltage to 122 volts for another 5 seconds.

2. Emergency frequency test (Figure 15).

MIL704D :EMERgency :FREQuency

This test will step down the frequency to 360 Hz for 5 seconds then will step up the frequency to 440 Hz for 5 seconds.

3. Emergency test

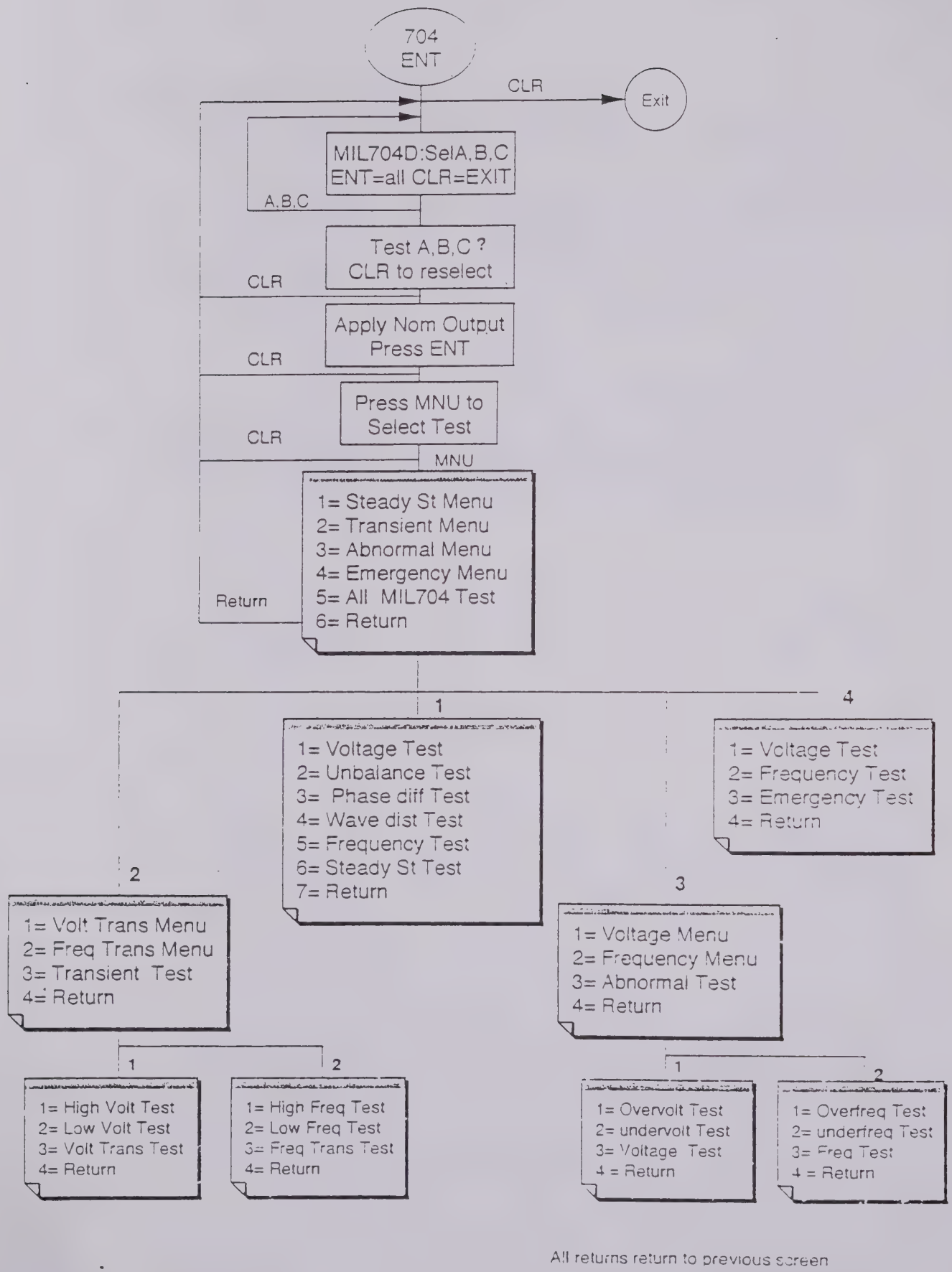
MIL704D[A][B][C] :EMERgency

This test will combine the voltage emergency test and the frequency emergency test. A pause of 5 seconds between tests is asserted.

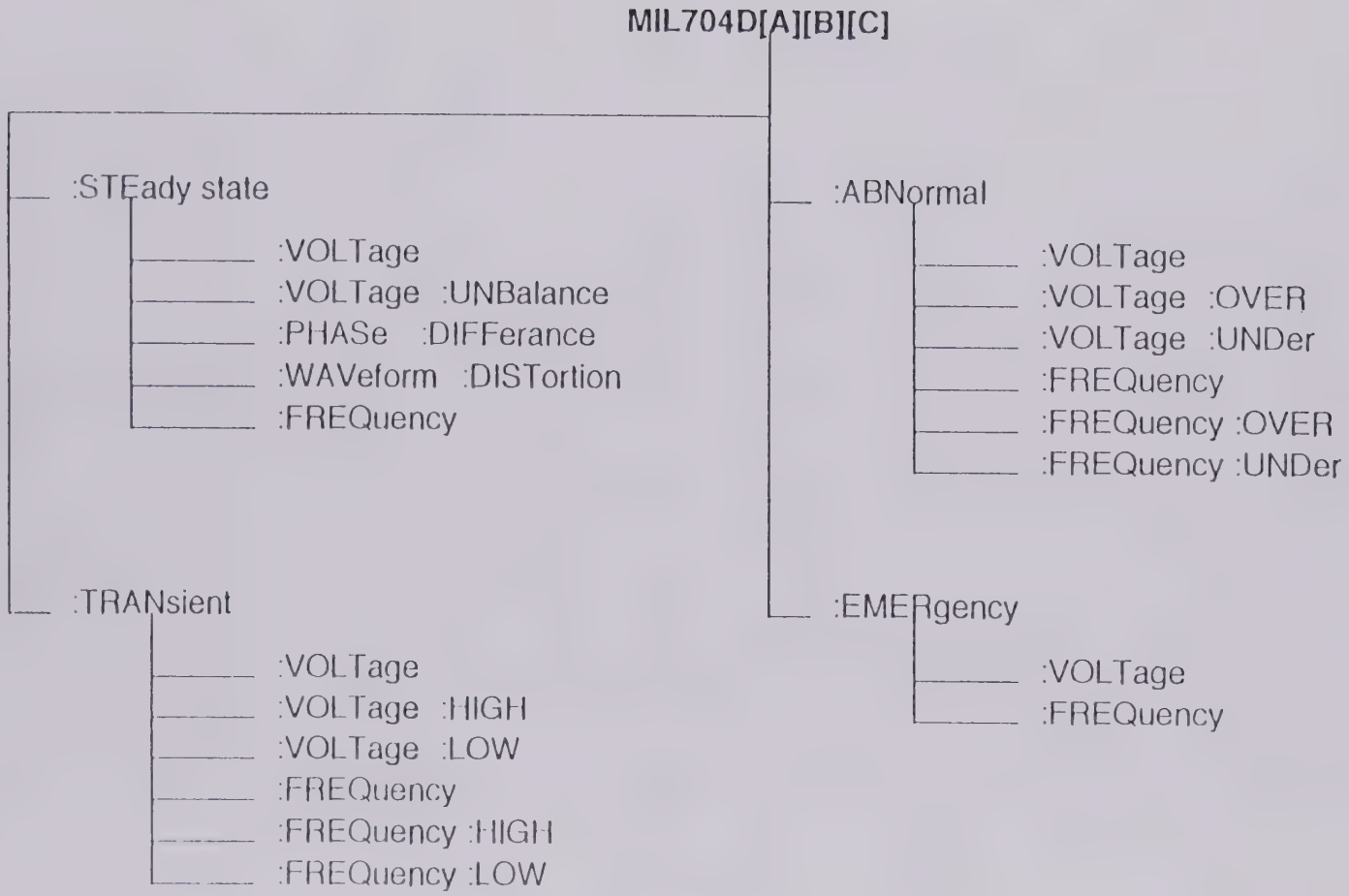
8.6.5 MIL704D TEST

MIL704D[A][B][C]

This test will combine all the tests listed above in one test in the sequence listed. A 5 second time delay separate the parts of the test. Tests will be performed on the selected phases only.



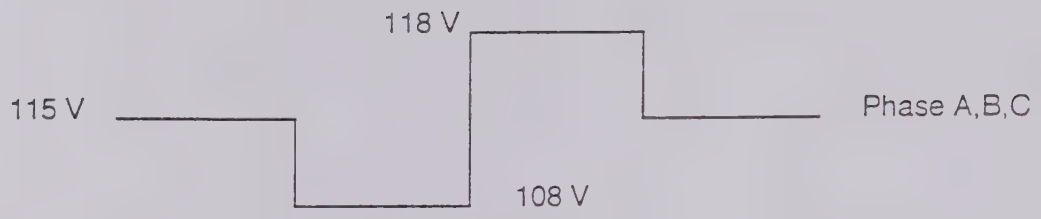
All returns return to previous screen



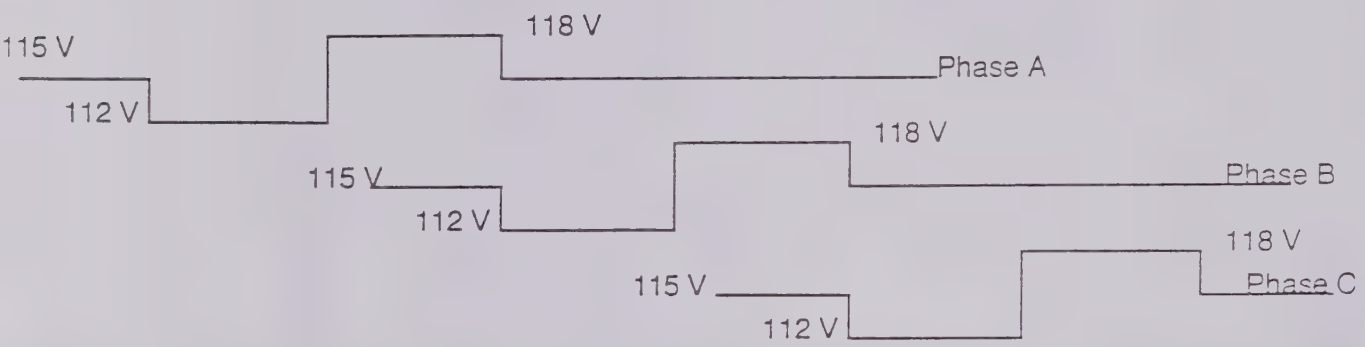
MIL704D SYNTAX FLOW

Steady state

Voltage figure 1

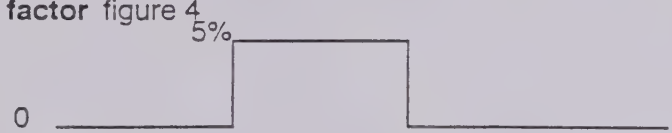


Voltage Unbalance figure 2

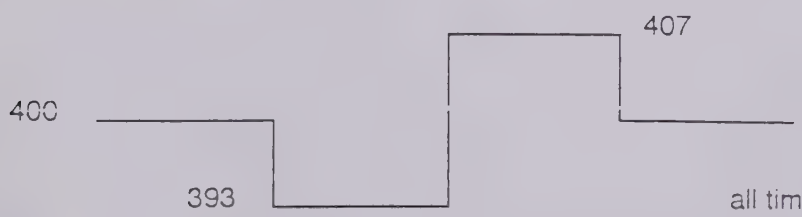


Voltage Phase difference figure 3

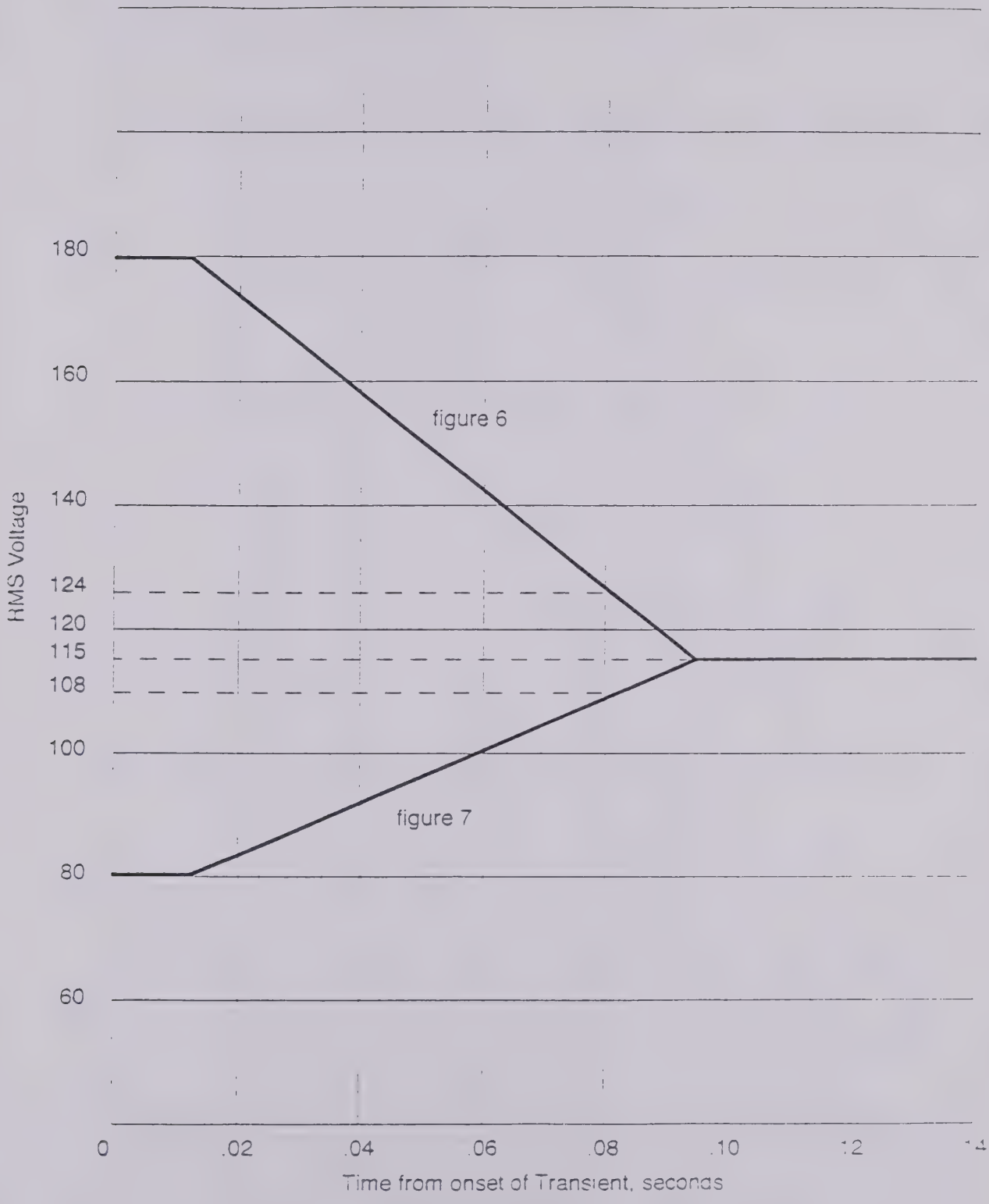
Distortion factor figure 4



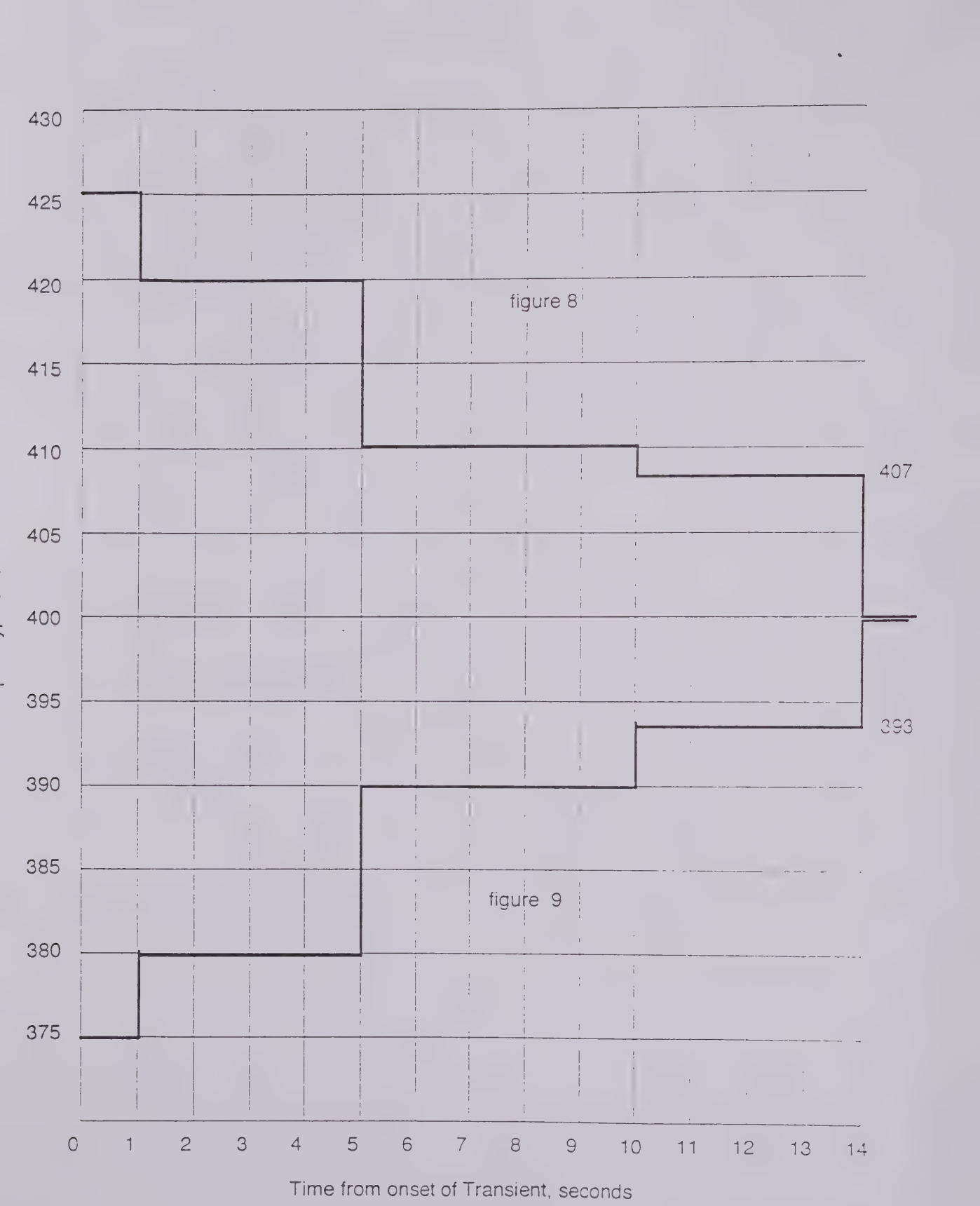
Frequency figure 5



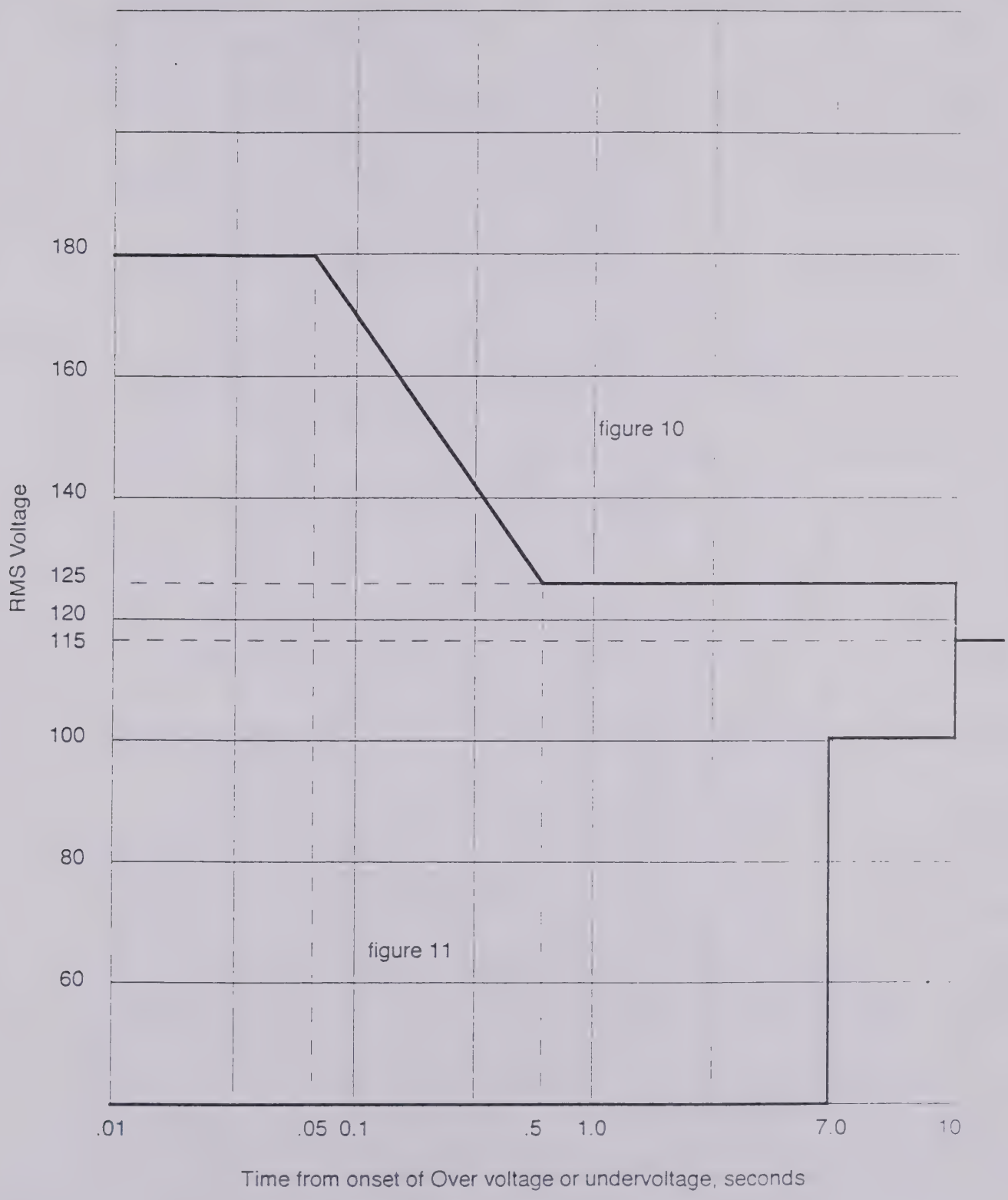
all time interval are 5 seconds



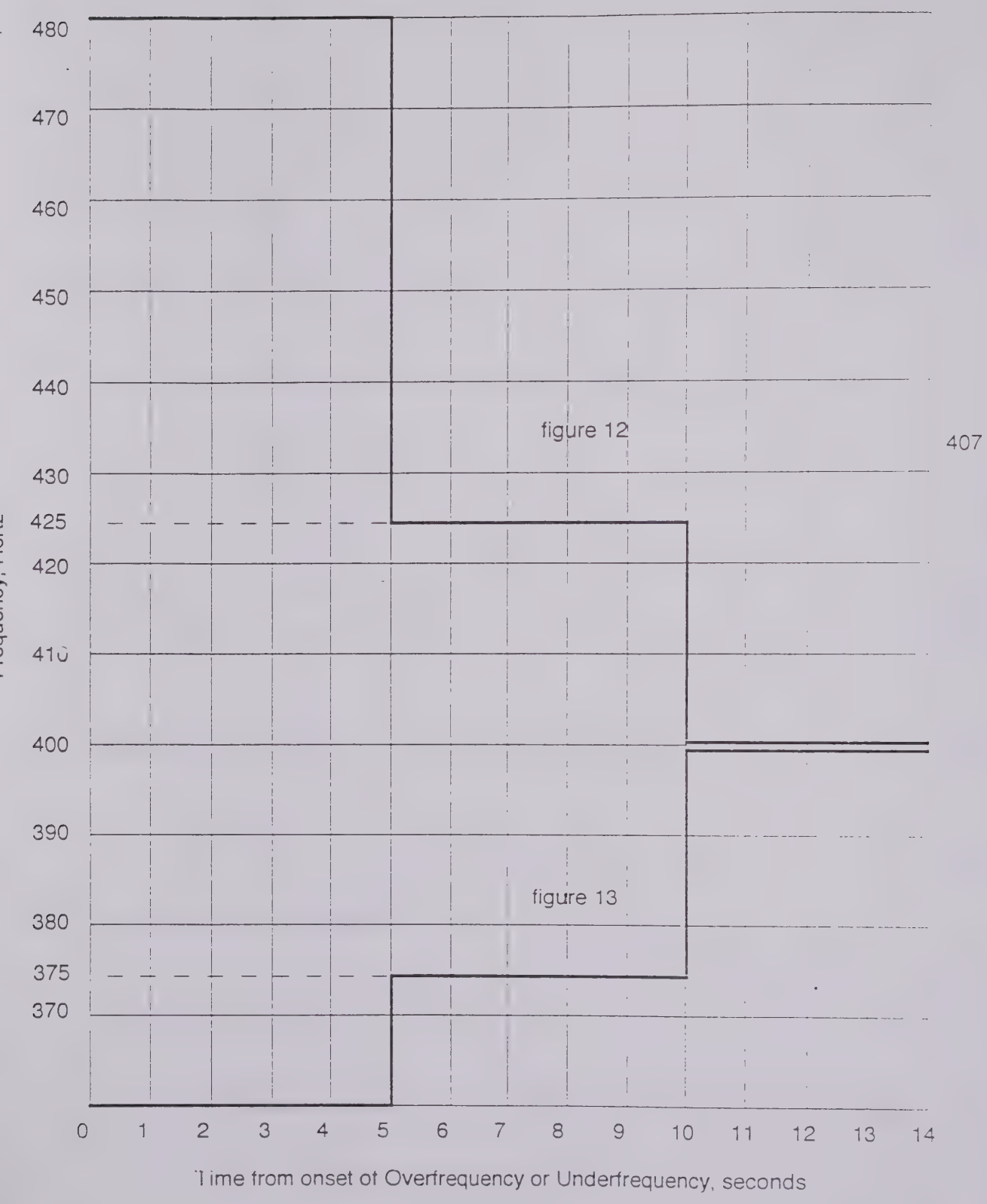
Voltage transient
figure 6,7



Frequency Transient
figure 8,9

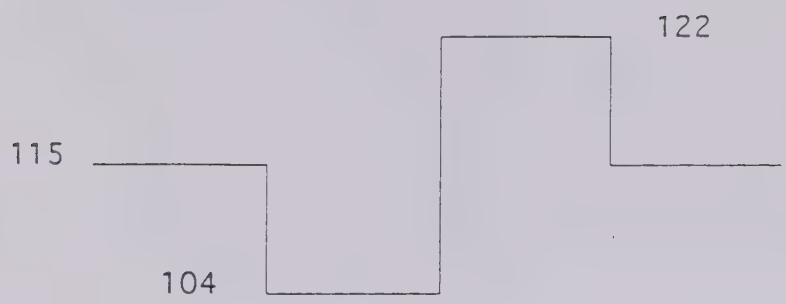


Abnormal operation
figure 10,11

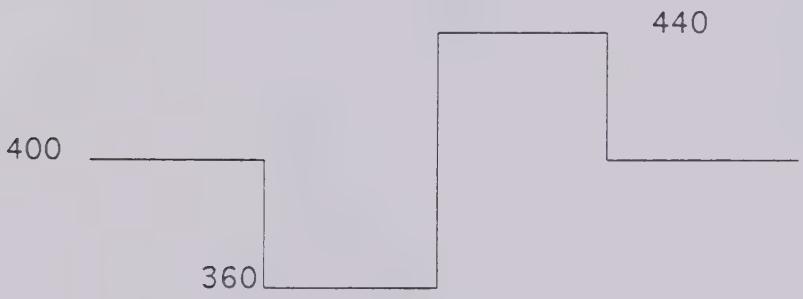


Abnormal Frequency
figure 12,13

Emergency Voltage figure 14



Emergency Frequency figure 15



all time interval are 5 seconds

SECTION 9

2-PHASE OPTION (2P)

9.1 GENERAL

The output appears from the Phase A and Phase C output terminals for this option. Phase C leads Phase A by 90 degrees.

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Weadon,Surrey	GB
0000S(28564)	SPCO(A Metac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
0000Z(52745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	LaFrance	Philadelphia	PA
000AH(54362)	Jan Crystal	Ft. Myers	CA
000AL(53495)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AW	Ritz Instrument Transformer	Redondo Beach	CA
000AZ	Switches Incorporated	Mt. View	CA
000AT(82643)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(61837)	Semi Processes, Inc.	San Jose	CA
000AW	Nitron	Chatsworth	CA
000AX(63878)	Apicernics	Hanstor	GB
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(61271)	Fujitsu	Santa Clara	CA
000BA(61944)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BD(55982)	Electronic Essentiale	Woodside	NY
000BE(57856)	Kel-Am	Elden	MO
000BF(55285)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54186)	Micro Power Systems	Santa Clara	CA
000BJ(06774)	Robinson Nugent	New Albany	IN
000BL(13130)	Beau Products (Varnitron)	Lacomia	NH
000BM(91725)	Corporainder (Cerrard AJ & Co.)	Des Plaines	IL
000BO	Mitsuwiami Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secoa	Bagnolet	France
000BS	Pana Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Gee Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Calicraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Use Code 172136		
03307	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Claires Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	J-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07080	Raiwin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Omitcast Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IPC Incorporated	Burrington	IA
07910	Use Code 115818		
08028	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Sparq Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Ampamol)	Garden Grove	
08289	Bilan Deibert Co.	Pomona	CA
08353	Bristol Co. of Canada	Taronato, Ont	Canada
08730	Oakby & Barron (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09153	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
11415	Cherry/Textron (Fastener Div)	Santa Ana	CA
12404	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Varnitron Corp (Beau Prod.)	Lacomia	NH
13606	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semtech Corporation	Newbury Park	CA
14606	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stonehan	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Amcom Ent (Rodan Div)	Anaheim	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amico Teledyne, Inc.	Mt. View	CA
15912	Analex	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Unpcb	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scamde Mfg. Co. (Bare Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	Robison Company	Hawthorne	CA
21808	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Bastings-on-Hudson	NY
23936	Pawnor, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24644	General Semiconductor Inc.	Tempe	AZ
24796	Paralax, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26804	American Letteler, Inc.	Costa Mesa	CA
27014	National Semiconductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Inc.	St. Garland	TX
27715	P-Ovne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28806	Echlin Ltd.	Rexdale Ont.	Canada
29377	Raymond Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segundo	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Dercan Company	Sylmar	CA
30983	Electra/Midland (Mepco/ Electra)	San Diego	CA
31827	Budwig Mfg. Co.	Ramona	CA
31951	Thiokol, Inc.	Pittsburg	PA
32293	Interail	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Klingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Colber Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Porter-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Mouser Corp.	Santee	CA
51167	Arlen Electronics, Inc.	Freehstown	NJ
51506	Accurate Screw Machine Co.	Hutley	NJ
51705	ICO/Bally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Kinces, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camarillo	CA
55122	Samtec, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Eel-Am, Inc.	Elden	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Kicor, Inc.	Milditas	CA
61394	Semi Technology, Inc.	San Jose	CA
61641	Seronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Denkircon Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Electro Motive Div.	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
73082	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Reinemann Electric Company	Trenton	NJ
74545	Hexrey Bubbell, Inc.	Bridgeport	CT
74868	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Bulka Electric Corporation	Mt. Vernon	NY
75382	Lawton Mfg. Co.	Little Neck	NY
75915	Littlefuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77062	Pabst Eng. Equipment Co.	Elizabeth	NJ
77132	Omitcast Inc., Paknin Div	Waterbury	CT
77342	Potter and Bluefield Div, AMF	E. Princeton	IN
78189	Shakeproof Div. IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79136	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kominoer Inc.	Long Island City	NY
79963	Ilerick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81095	Triad Transformer Corp	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81660	Nacs Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82189	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc	Sylmar	CA
83330	Herman H. Smith, Inc	Brooklyn	NY
83486	Elco Tool & Screw Corp	Rockford	IL
83500	Brady W.H. Co.	Milwaukee	WI
83684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc	Glendale	CA
87034	Varo-Vmian Industries	Anaheim	CA
88245	Jaeco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91967	National Tel-Tronics	Readville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94722	Sourdeo, Inc.	Exeter	PA
94696	Meanecraft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	Wp. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95987	Weckesser Company, Inc.	Chicago	IL
96906	Military Std		
97515	Electronic Engineering Co	Santa Ana	CA
98159	Rubber Tech, Inc.	Gardena	CA
98291	Sealetto Corp.	Mamaroneck	NY
98376	Tara Mfg. Co. (West)	Burbank	CA
98978	IEEC	Burbank	CA
99017	Protective Closures Co., Inc. (Capiugs Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delavan	WI
99742	Permacell	New Brunswick	NJ
99743	IMC	Haywood	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

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